ITTING
CHARTS

W. G. SNOW

Pipe
ing Charts

Pipe Fitting Charts

For Steam & Hot Water

Also Galvanized Iron Piping
For Fan and Indirect Systems

By William G. Snow

Appendix Relating to Piping, Containing Reprints of Articles from the "Metal Worker" and other publications.

DAVID WILLIAMS COMPANY
239 WEST THIRTY-NINTH STREET, NEW YORK, N. Y.
1912

Gift of
Mrs. George Beach

THE · PLIMPTON · PRESS · NORWOOD · MASS · U · S · A

PREFACE

In response to numerous requests, the articles by the author relating to piping connections, which have appeared in the Metal Worker have been rearranged, added to and put in the form herewith presented, which it is hoped will be found convenient for reference.

It is assumed that the reader is familiar with the elementary systems of piping for steam and hot water, illustrated in many treatises on heating. This book deals with piping details, not with general heating layouts.

It has not been attempted to illustrate to any extent the methods of piping in patented or proprietary systems of heating, as the manufacturers of the devices used in connection with these systems as a rule publish abundant literature illustrating and describing methods of application.

While in no sense complete, the charts given on these pages will doubtless suggest methods of piping to accomplish certain ends, and in connection with the appendix will, it is hoped, form a useful addition to the literature on the subject.

CONTENTS

PIPE FITTING CHARTS

CHAPTER I

Piping for Hot Water Heating

Figs. 1*a* and 1*b* show the plan and side elevation of a cast iron sectional hot water boiler. The connections on the top may be made more easily with the main at one side than when placed directly over the outlets, which may happen to be tapped crooked.

The main return at the rear enters an equalizing pipe connected near the middle of each side. It is practically as well to connect at the rear of the boiler, except in the case of unusually long ones, which should have the returns connected near the middle to secure a fairly uniform flow through the sections.

A hot water thermometer should be connected with the flow pipe.

The water supply connection for filling or replenishing the system is made as indicated in the main return near the boiler.

A plug cock should be placed at the lowest point in the system and connected with a drain or left with a hose nipple.

A damper regulator, controlling the draft and check dampers, is a desirable addition to a hot water boiler, the operation of the regulator being effected by a difference in temperature of the water. One type of regulator is shown in Fig. 1*b*.

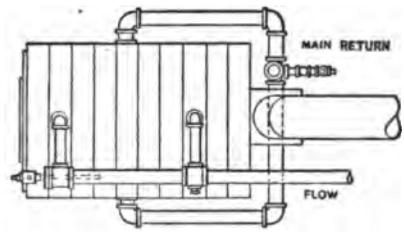


FIG. 1*a*. — Plan, Hot Water Boiler

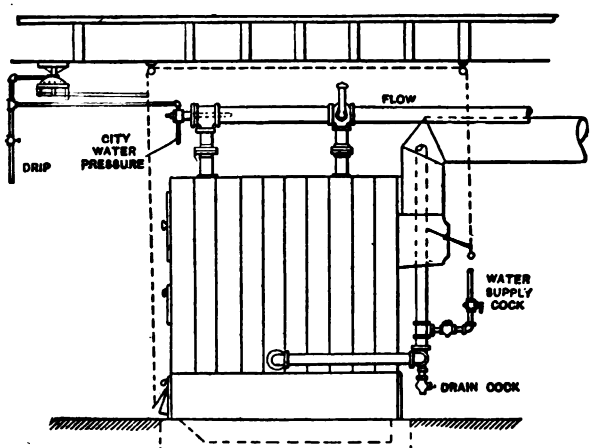


FIG. 1*b*. — Elevation, Hot Water Boiler

Figs. 2*a* and 2*b* show the plan and side elevation of a pair of hot water boilers connected so that either or both may be used.

A relief or safety valve with a non-corrosive seat should be placed on each boiler. These valves may be either the spring or weighted lever pattern.

The dotted lines represent the overhead returns with which the cold water pipe is connected at some point outside of return valves, the supply being controlled by a cock or a lock shield globe valve, to prevent any tampering by persons not in charge of the apparatus. Cold water to make up any deficiency in the system is generally admitted to a return line, where it will not tend to retard the flow.

A thermometer is indicated at end of top drums in elevation. A damper regulator, though not shown, should be used.

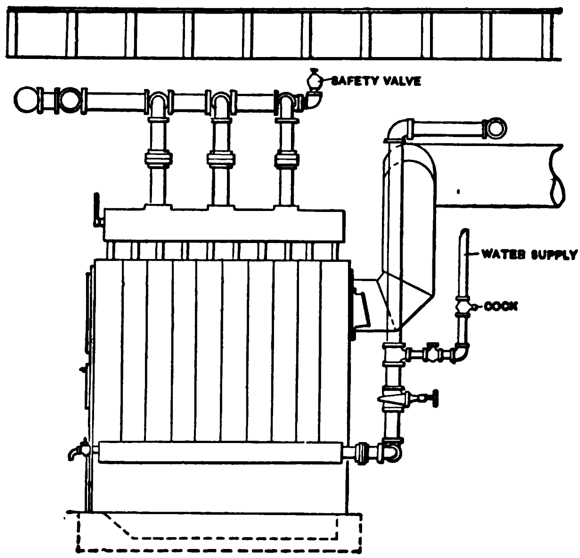


FIG. 2*a*. — Elevation, Hot Water Boilers

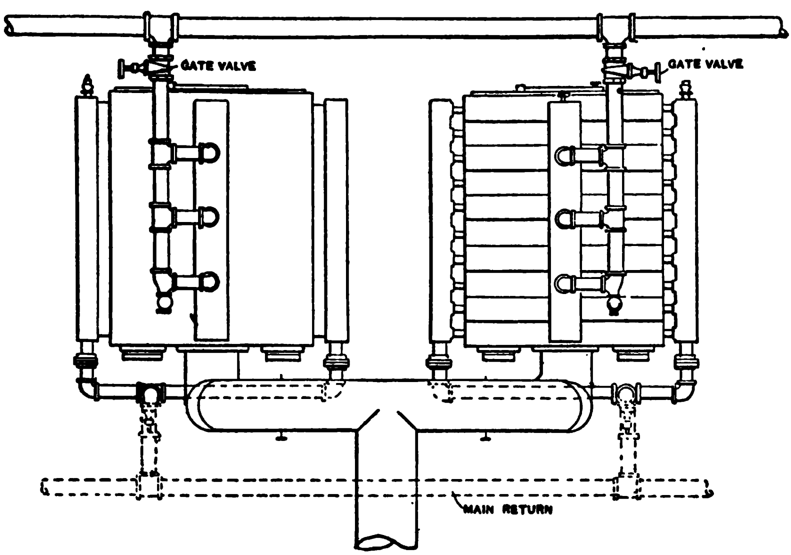


FIG. 2*b*. — Plan, Twin Hot Water Boilers

Fig. 3 represents a group of fittings used in hot water heating. A shows a long turn elbow which offers considerably less resistance than the standard elbow. B shows a long turn twin elbow which guides the water with very little resistance. C shows an O/S distributing tee, very commonly used in risers, more particularly the supply lines. D and E show a quick opening valve and a union elbow, and F a separable bulb thermometer. All pipes should be reamed to remove rough, sharp edges; otherwise the flow will be much impeded. Pipe joint lubricant or filling should be applied to the male thread only. It is a great mistake to swab the threads of the fittings with this material, for it is then pushed into the pipe when the joint is made up.

In Fig. 4, showing several branch connections, A shows the manner in which branches near the boiler or those leading to upper floors should be connected with the main.

B and C show how branches should lead from the main to radiators on lower floors. The connections shown in C favors the flow of water to a radiator somewhat more than the method shown in B. It makes but little difference whether the returns are connected with the side of the mains, with the top or at 45 degrees. The supply mains should, if possible, pitch upward in the direction of flow 1 inch in 10 feet

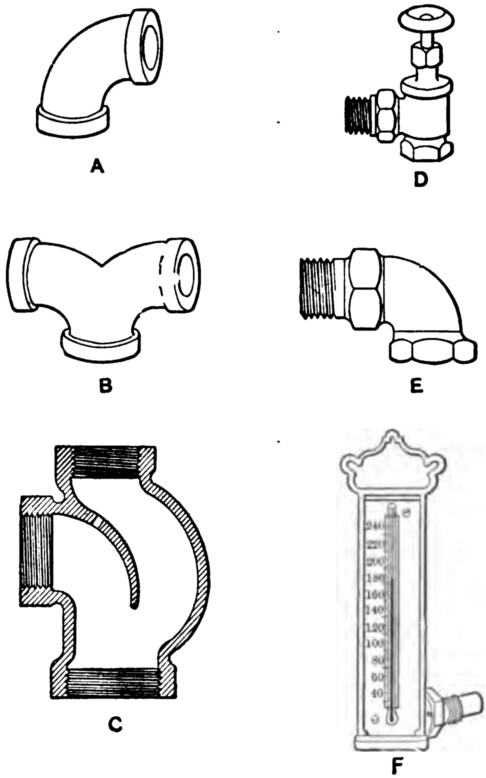


FIG. 3. — Hot Water Valves, Fittings and Thermometer

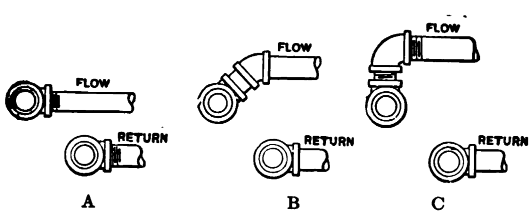


FIG. 4. — Branch Connections

Fig. 5 shows the method of connecting with main the branches to radiators in different locations as to height or distance from the boiler.

Fig. 6 shows a branch connection with riser fitted with a valve and a drip cock. This arrangement is especially good in systems of considerable extent, as in case of a leak or changes only a small part of the system would have to be shut down, where otherwise all the water might have to be drawn off. The stop valve, gate pattern, is located between the 45 degrees elbow and the drain cock.

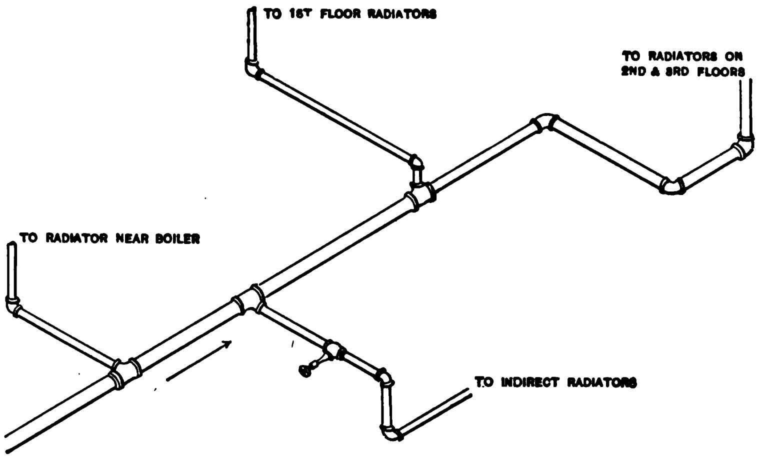


FIG. 5. — Supply Branch Connections

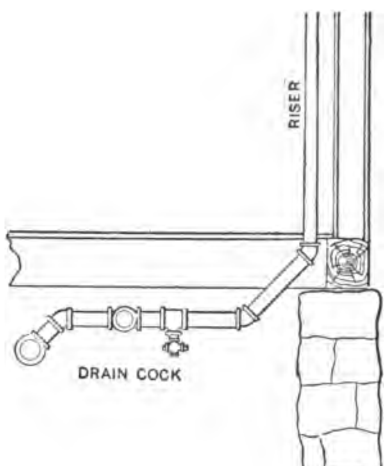


FIG. 6. — Riser Connection

Fig. 7 shows branch connections which may be concealed in floors. The pipes leading to the left are to radiators on the lower floor, those to the right leading to floor above. It will be noted that the lower floor is favored by being taken from the run of the tee, as the water flowing up the riser tends to continue in a straight line.

Fig. 8 shows an application of the connections illustrated in Fig. 7. A quick opening valve with union is placed near the bottom of the radiator, in which case a retarder or wooden plug is often placed in the lower nipple between the first and second sections of the radiator to cause the water to rise to the top of the first section, thence through the nipples connecting the sections at the top.

A union elbow is shown at the opposite end of the radiator.

The air valve on hot water radiator is always located at the highest point and should preferably be of the key pattern.

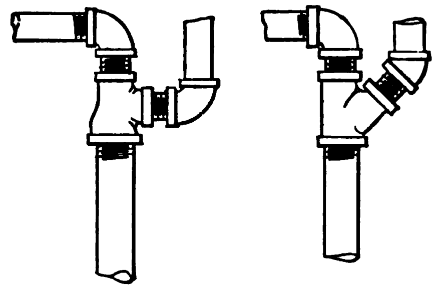


Fig. 7. — Riser Branch Connections

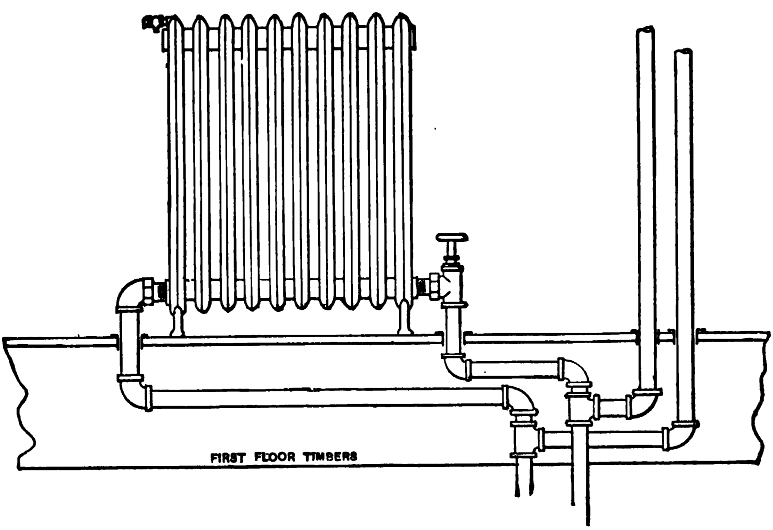


Fig. 8. — Riser Connections

Fig. 9 shows very simple radiator connections with a quick opening valve at the top and a union elbow at the bottom at opposite end. This location of valve is more convenient than that shown in Fig. 8 but is rather conspicuous for radiators in finely furnished rooms.

Fig. 10 shows connections with a "stack" or "bench" of indirect radiators. One valve is all that is necessary to give control, but it is well to use two to provide for making repairs without shutting down too large a part of the system, assuming that it is divided into sections by main valves. To save expense and avoid danger from freezing, both valves are, in many jobs, omitted, the control of the heating being secured by means of the register.

For hot water heating deep sections should be used to insure the proper heating of the air.

Particular care must be paid to air venting indirect systems.

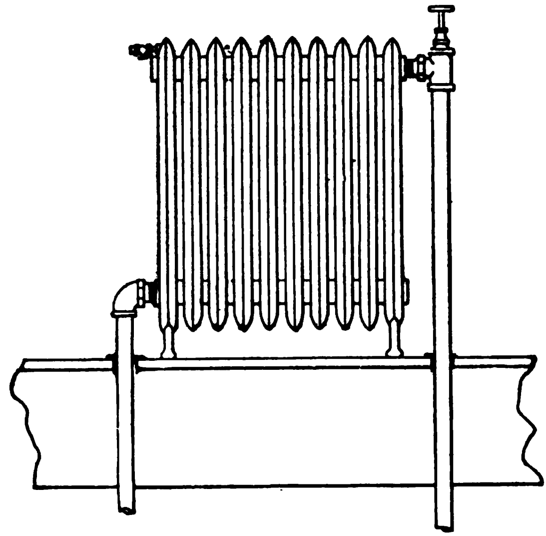


FIG. 9. — Radiator Connections

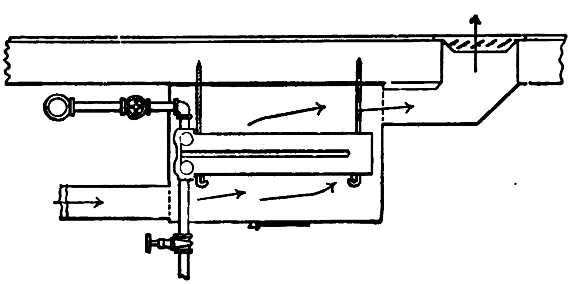


FIG. 10. — Indirect Radiator Connections

Fig. 11 shows a manifold coil and connections with distributing tee in a down-feed riser, the water from the coil returning to the same riser. Connections may be made larger than in the case of return-bend coils. The valve shown is union gate pattern. The air vents up the riser.

Fig. 12. — This type of radiation is adapted only to relatively small units, since if the surface exceeds the capacity of the pipe the lower lines will be cool and inefficient. The valve shown is a union gate.

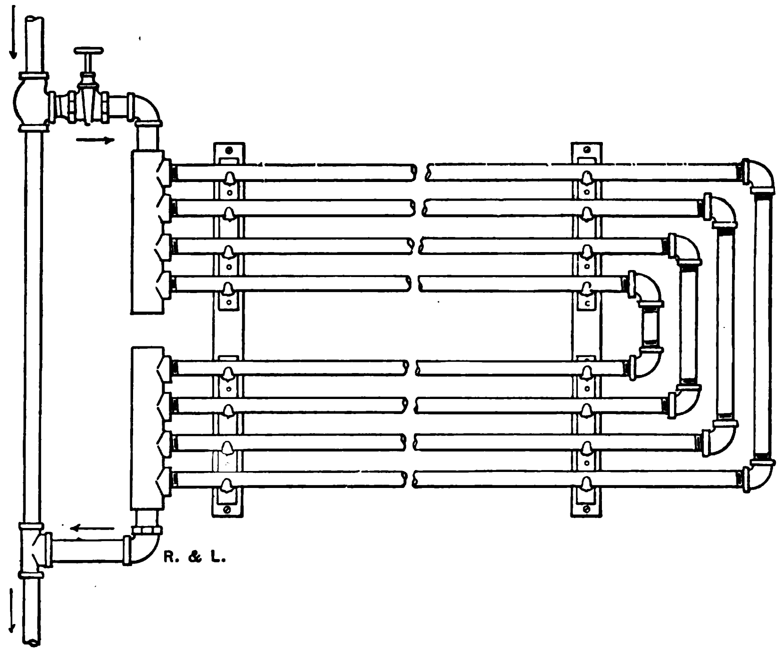


FIG. 11. — Manifold Coil Connections

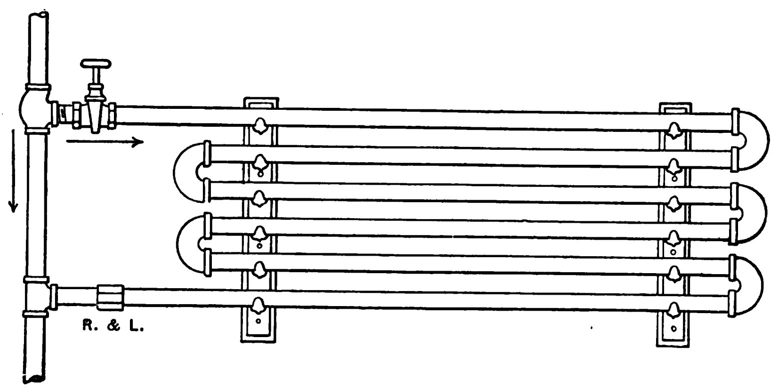


FIG. 12. — Return Bend Coil Down-Feed Connections

Fig. 13 shows a "return-bend" or trombone coil connected with an up-feed system.

A quick opening supply valve with union, a right and left coupling and air valve are shown.

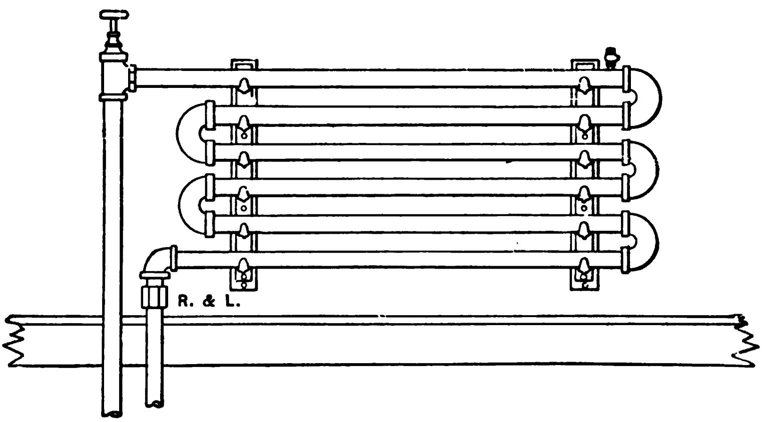


Fig. 13. — Return Bend Coil Up-Feed Connections with Quick Opening Union Valve

Figs. 14*a* and 14*b* illustrate the ordinary two-pipe up-feed system, with concealed risers and branches and quick opening union valves. The risers must be thoroughly tested and covered before being closed in. In the better class of residence work this method is commonly employed.

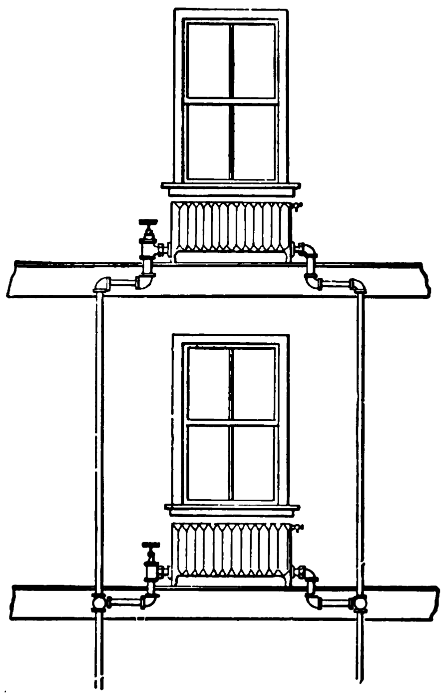


Fig. 14*a*. — Elevation, Radiator Connections, Up-Feed

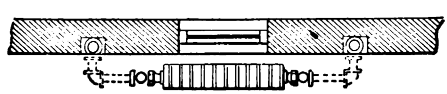


Fig. 14*b*. — Plan, Radiator Connections Concealed

Figs. 15*a* and 15*b* show a two-pipe up-feed system, with exposed risers, the branches from distributing fittings being concealed under the floors, either between beams or run through notches in them, which is permissible if the notches are made near the bearings of the beams. In case holes are bored through the timbers they should be made on the center line, which will weaken the beam less than if cut near top or bottom.

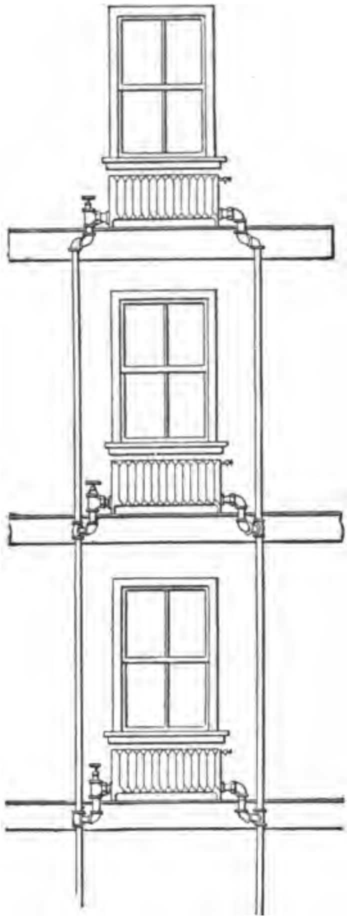


Fig. 15a. — Elevation, Radiator Connections Up-Feed

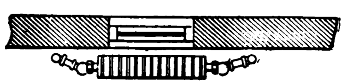


Fig. 15b. — Plan, Radiator Connections

Fig. 16 shows an ordinary overhead feed system of risers, the radiators, to use an electrical term, being placed in parallel — that is, the water passes through each separately, then enters the return, so that each radiator receives water of the same temperature (neglecting the slight loss due to the radiation from the supply riser). This system is therefore applicable to buildings of many floors. The valves are shown in the most convenient location. When shut the radiator will not become cold, as a slight double circulation is set up through the return connection, the cooled water flowing out from the radiator through the lower half of the pipe and entering through the upper portion.

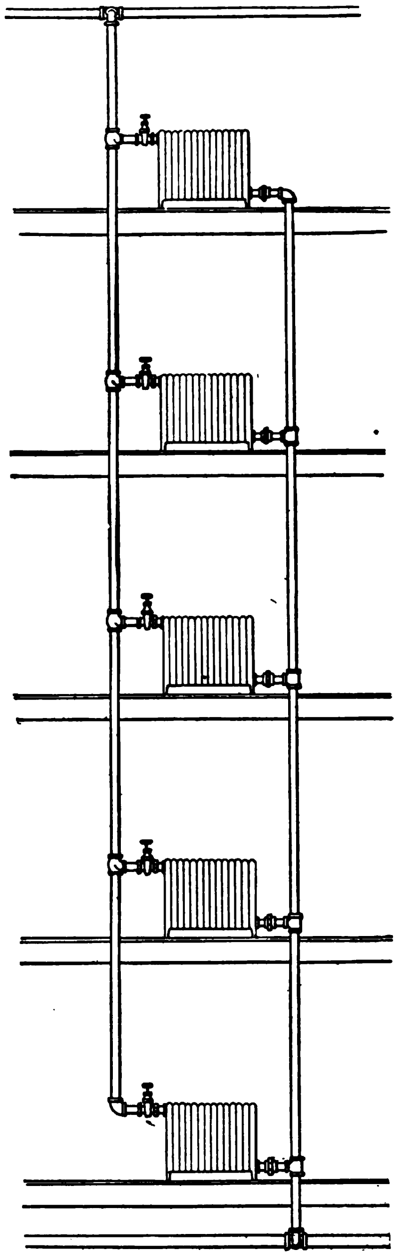


FIG. 16. — Radiator Connections Down-Feed System

Fig. 17 shows an overhead feed one-pipe system suitable for residences and low buildings. These radiators, it will be noted, are so connected that the water flows through them successively from top to bottom of the building and, of course, becomes cooler the lower it descends, the discharge from each radiator mixing with the water passing directly down the riser. Hence, radiators on lower floors must be made larger in proportion to the space heated than on floors above, since they give out less heat per square foot of surface.

The single pipe feature and the fact that no air valves are required on the radiators, since the air escapes to the expansion tank, commend this system in buildings where overhead feed pipes may be run.

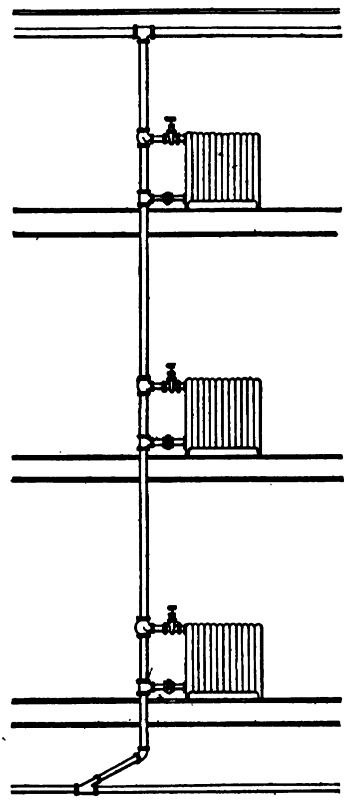


FIG. 17. — Single Pipe Down-Feed Radiator Connections

Fig. 18 shows a portion of an overhead distributing system. The main riser R discharges through a twin elbow to mains with which branches to the several risers are connected. Lines leading to the expansion tank should be connected at A, and mains should pitch upward toward these points from the ends of the lines, so that all air will freely escape. Branches to risers should be taken from the bottom of mains, and on work of considerable magnitude should have a stop valve at top and bottom of each riser.

Fig. 19 shows a small apparatus with radiators and boilers on the same floor. The successful working of such a system depends on the overhead feed through the expansion tank, which acts as a cooling coil and, in conjunction with the radiators and pipes, cools and increases the weight of the water per unit volume, causing a preponderance of weight over that of an equal height of water in the boiler and upward flow pipe, thus causing the water to circulate.

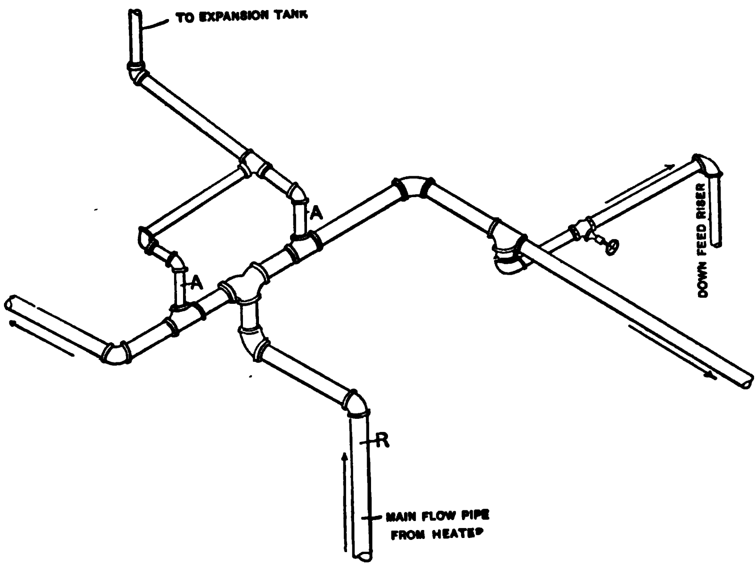


FIG. 18. — Overhead Feed Mains and Branches

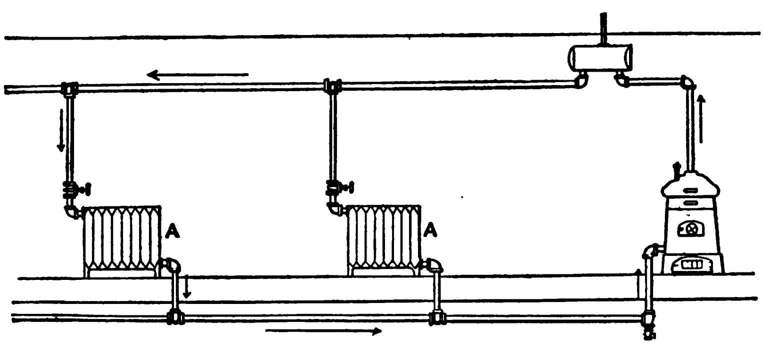


FIG. 19. — Piping with Radiators on Same Level as Boiler

Fig. 20 shows a typical expansion tank. In place of a water gauge, however, try cocks are preferable, as they involve no danger of damage from a broken glass.

The expansion pipe is connected with the bottom of the tank and should lead to one of the return lines in the basement. The pipe will then stand full of cold water and a higher temperature may be carried in the system without boiling the water than when the expansion pipe is connected with one of the flow pipes.

The overflow and air vent is shown at the top of the tank. This line may be carried out through the roof or to other convenient point of discharge where no damage would result from a sudden discharge of water from the tank.

No valve must be placed on the expansion pipe.

The dotted line represents a circulating pipe for use when the tank is located in a place where the water in it or in the pipes connected with it is liable to freeze. This circulating pipe is intended to be connected with one of the flow pipes of the system.

The greatest care must be exercised in locating tank and pipes to guard against freezing, since the expansion tank is the safety valve of a hot water heater, and if it or the pipes connected with it freeze or a valve is placed in the expansion pipe and is closed an explosion is likely to result from a freshening of the fire.

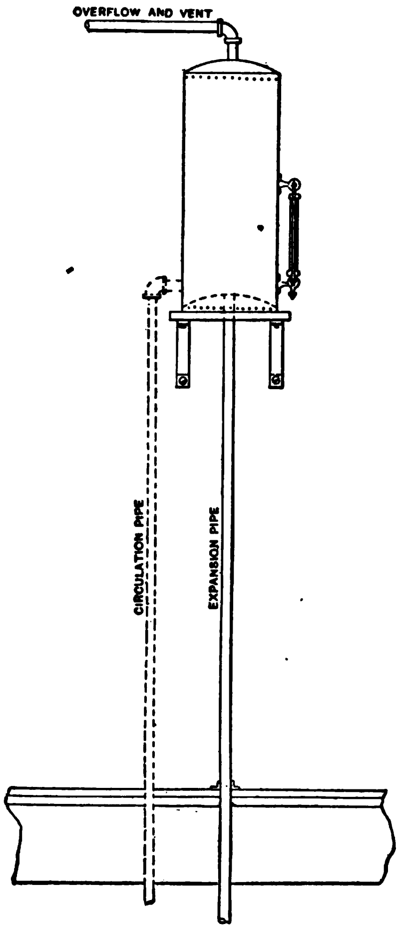


FIG. 20. — Expansion Tank Connections

CHAPTER II

Piping for Steam Heating

Fig. 21 shows a typical arrangement of a steam heating boiler for low pressure. The water supply should preferably be controlled by a plug cock with a removable handle. It is better to place the drain cock at some other point than at the bottom of the water column connection where the opening of the cock would affect the indication of the water gauge. Provide a separate cock for draining piping without emptying boiler. The safety valve may preferably be located where shown instead of at the top of water column connection, where a blowing of the valve would tend to cause a siphoning of water from the column and a faulty indication of the glass.

The present form of damper regulator with a chamber in which the steam is condensed, the water filling the space below the diaphragm, is far preferable to the old style with the regulator perched on top of a pipe some distance above the water line in the boiler. The present pattern is far more sensitive.

It seems hardly necessary to illustrate the arrangement of connections with twin boilers. Practice differs greatly in the manner of making these connections. Many fitters connect the main steam pipes with a header of ample size, say twice the diameter of the pipes from boilers, and use no equalizing pipe whatever between them. Other fitters consider an equalizing pipe essential, in order to steady the water line. Such a pipe, if used, is connected directly with both boilers and has no outlets. A valve is placed between the boilers for use when one of them is out of service. Certain fitters recommend a similar connection below the water line, but many successful plants are in operation with no equalizer pipes whatever, care being taken to make the steam connections and header of ample size and to arrange the returns so that the water will enter one boiler as easily as the other.

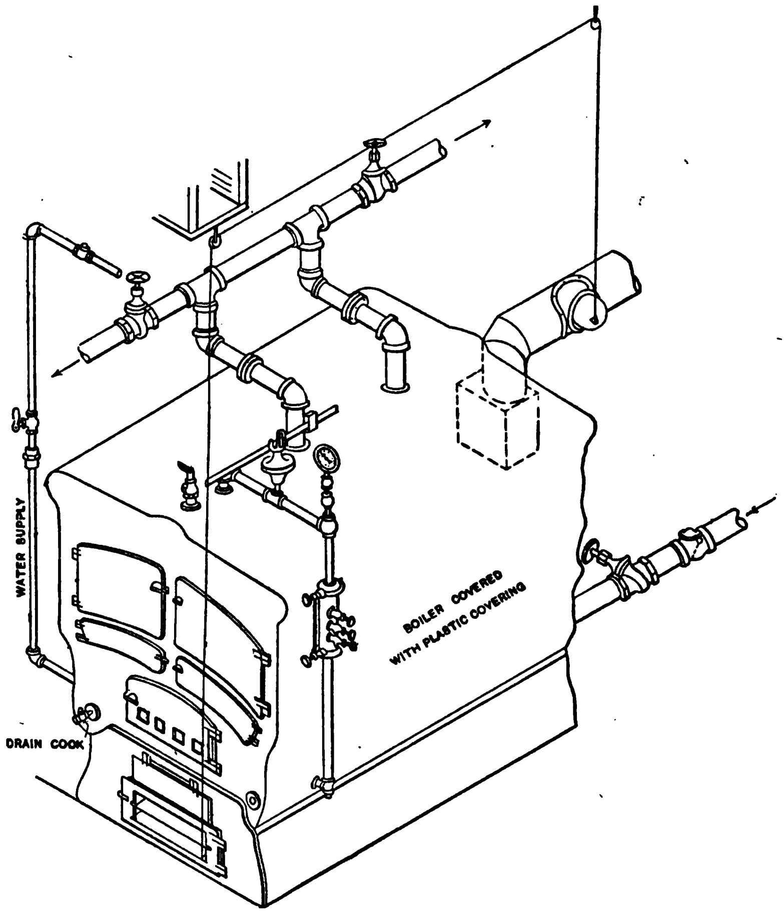


FIG. 21. — Low Pressure Steam Boiler Connections

Figs. 22*a* and 22*b* show the construction of an ash pit under cast iron sectional boilers. The bottom should be 4 to 6 inches below the floor level, to provide ample space for the accumulation of ashes below the grate. The bricks should be laid on edge lengthwise of the boiler and grouted in cement. If laid flat they are likely to be pulled out of place by hoe or shovel.

Fig. 23 shows a boiler pit for use when boilers must be set below basement floor level to secure a gravity return. The walls should be made 8 to 12 inches thick, according to their height, the top or curb being finished with bricks laid on edge. The bottom of the pit should be paved in the same manner.

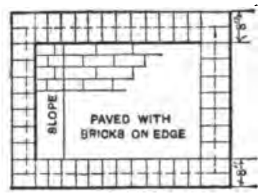


Fig. 22*a*. — Plan Ash Pit

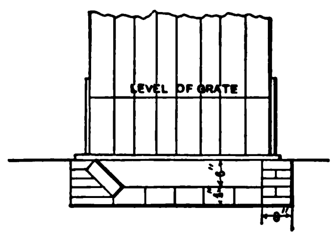


Fig. 22*b*. — Section Through Ash Pit

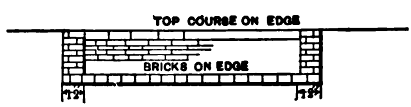


Fig. 23. — Section Through Boiler Pit

Fig. 24 shows the simplest of all steam heating systems, the one-pipe circuit. It is essential in this system that large pipes be used, as the water of condensation flows through the same pipes as the steam, and ample space must be provided for both, if wet steam is to be avoided. The main rises to the highest point near the boiler, from whence it pitches downward back to the return opening of the boiler. The main is kept full size throughout. The branches should pitch sharply upward from the mains and may be taken off the top or from a tee set at an angle of 45 degrees.

The labor cost of erecting a circuit system is relatively low owing to its simplicity, and the cost of piping will not differ materially from the one-pipe relief system with its separate horizontal return lines.

The circuit system is well adapted to small buildings of compact form. Since the mains are all above the water line, there is no danger of freezing in exposed places. The system contains only the water that is in the boiler and is therefore affected more by variations in the condition of the fire than systems having water filled returns. With the latter more time must be consumed in raising the steam pressure, owing to the larger volume of water contained in the system. It is well to place an automatic air valve at end of circuit main at point where drop to boiler is made.

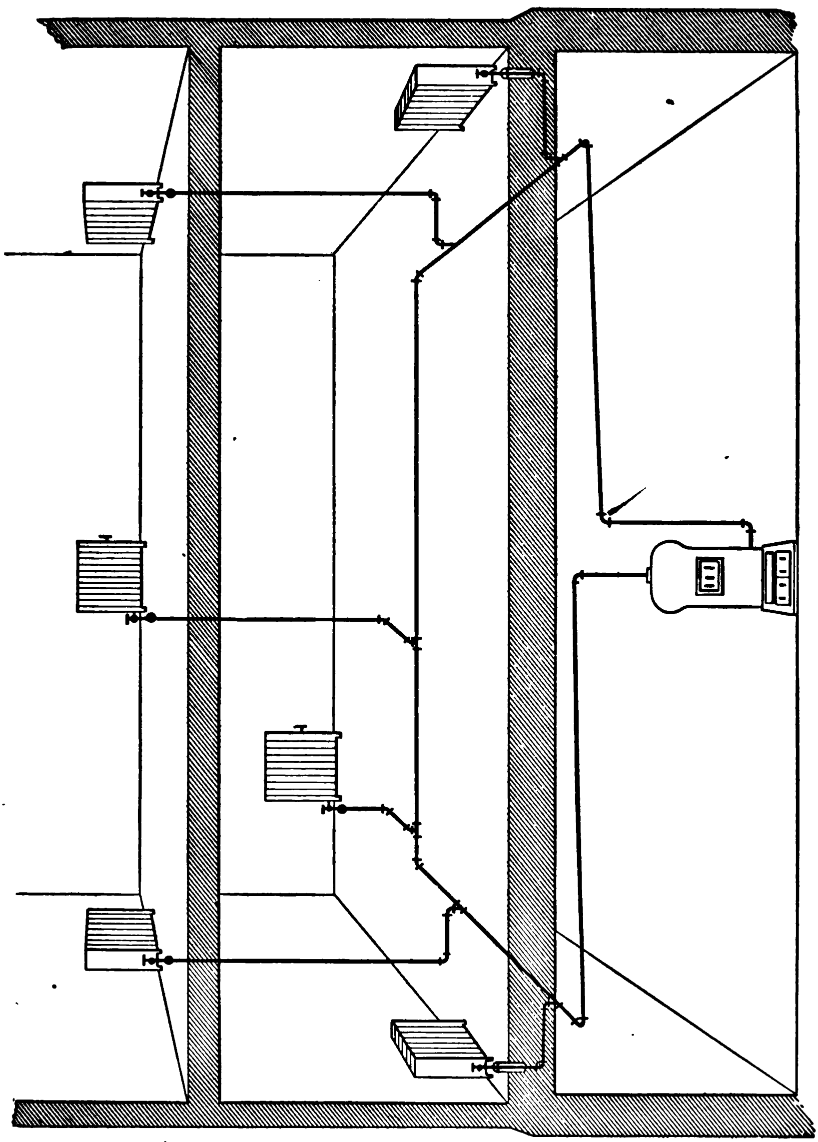


Fig. 24. — One-Pipe Circuit System of Steam Heating

Fig. 25 shows a common arrangement of basement piping for draining mains and risers of a one-pipe or two-pipe relief system. A single valve placed in the riser above the reducing tee accomplishes all that may be done by the two valves shown in the drawing and avoids interrupting the dripping of main when valve is closed.

When branch is taken off, as in "B," space is often lacking between branch and ceiling in which to place a shut-off valve in riser.

It is better practice to use a straight tee at the base of risers with a nipple and reducer, as shown in "A," in place of a reducing tee, as shown in the larger drawing. With the latter the steam tends to pick up the water of condensation flowing down the riser and to cause a noise at the junction of the horizontal and vertical pipes.

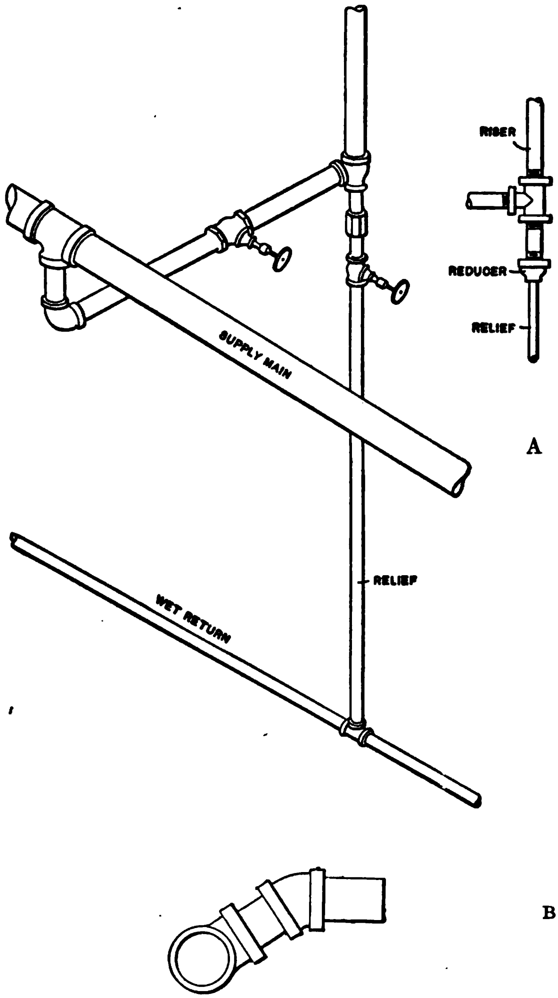


Fig. 25. — Basement Piping, Riser Connections

Fig. 26 shows the arrangement of basement piping in systems where the risers drain to the main, the latter being drained at the end. Note the manner in which provision is made for the expansion of the long horizontal main by means of swinging connections and nipples, the latter serving as swivels.

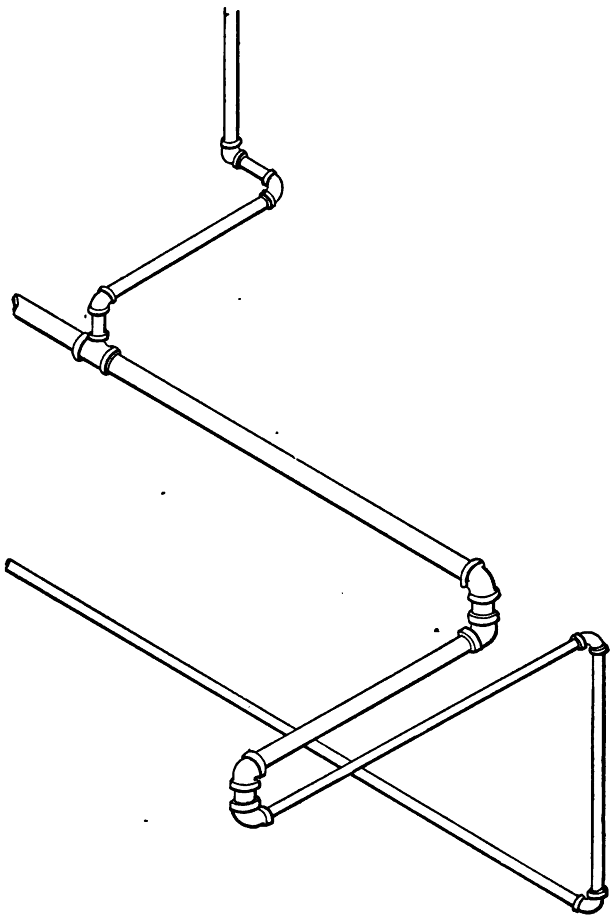


Fig. 26. — Basement Piping, Expansion Loop

Fig. 27 shows an arrangement of basement piping in which the supply risers drain to the main, a valve being placed at the base of each, the return risers discharging into a water sealed main return. The supply main is drained at the end. This method of piping is particularly applicable to the two-pipe vacuum system, the draining of supply risers to the main avoiding the use of a thermo valve or trap at the base of each. With the vacuum system a valve of the type mentioned would be required in the relief line at the end of the main and the stop valve in the return riser would be unnecessary.

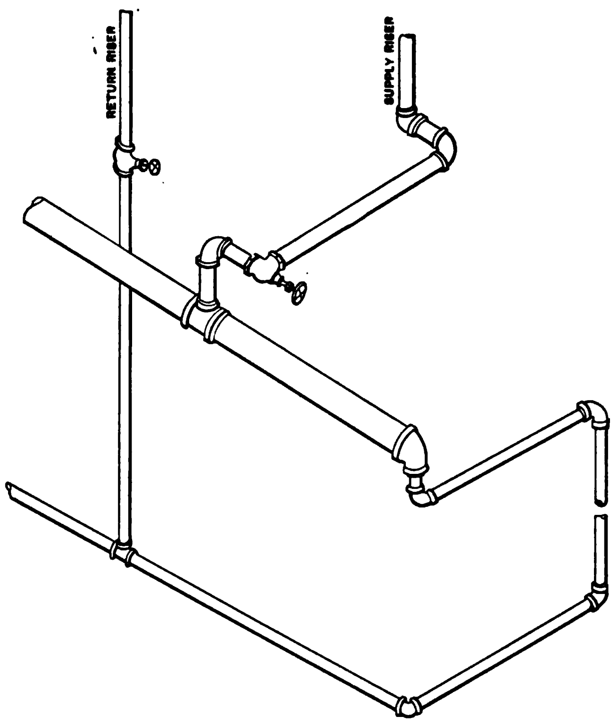


Fig. 27. — Basement Piping Riser Connections and Expansion Loop

Fig. 28 shows the proper arrangement of the connection between an overhead feed main and a riser. The connection is taken from the bottom of the main to provide for the removal at each branch of all condensation in the main between branches. A valve should be placed at the top and at the bottom of each riser in a building of any magnitude to provide for readily making repairs. The movement of the main is readily accommodated by the swinging of the lateral branch on the nipple C and on the thread at the top of the riser. The expansion of the riser is taken up by the movement of the branch turning on the nipples A and B. This arrangement provides perfectly for the expansion of both main and riser. Fewer fittings and nipples would not accomplish this; more would do the work no better. Often one sees a whole batch of fittings intended to provide amply for expansion, which will accomplish the purpose no better than half the number of fittings intelligently arranged.

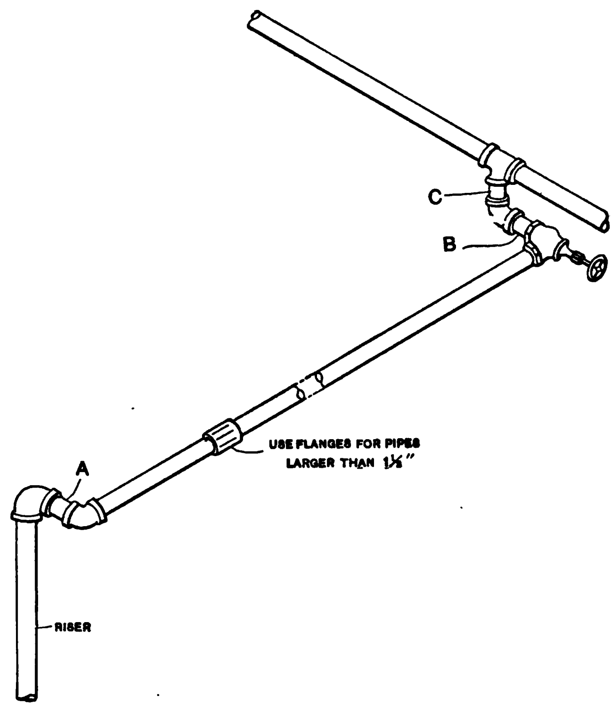


Fig. 28. — Riser Connections, Down-Feed System

Fig. 29 shows an arrangement of piping of an overhead feed system at the end of a long line where a turn is to be made and where any thrust against risers must be avoided. Where the right angled turn is made a pair of elbows and a nipple should of course be used, although it is surprising how often a single elbow is the only fitting put in. The expansion of the long main will cause the elbows to turn on the nipple D and will force the main E F over in the direction of the riser. The latter will not be forced out of position, however, due to the turning of nipples H and J.

The expansion of the riser is taken up by the nipple K and the thread at the horizontal outlet of elbow at L. The essence of the arrangement for taking up the expansion of mains and risers is in providing parallel nipples to act as swivels wherever the expansion is to be taken up.

Let the offsets be of considerable length; the longer they are the less will be the turning of elbows on nipples.

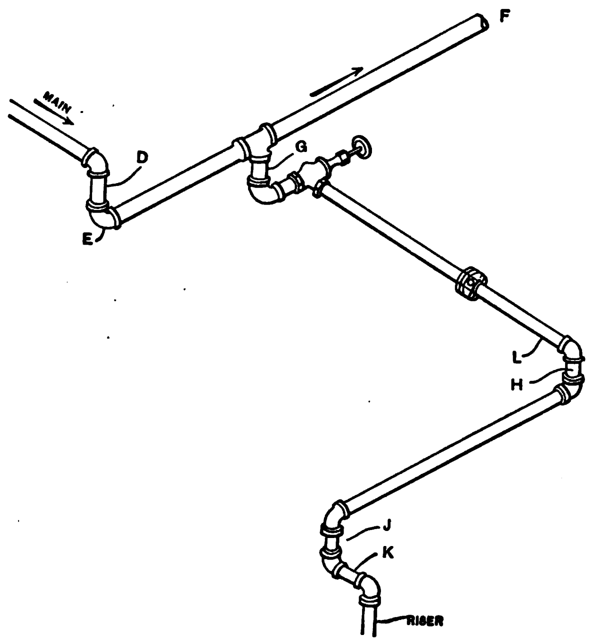


FIG. 29. — Overhead Feed System, Provision for Expansion

Fig. 30 shows a method of providing for the expansion of long mains. The vertical nipples give the necessary swivels or hinges and the dripped tees connected with traps provide for the removal of all condensation. Care must be taken in connecting with the traps to allow for the movement of the main.

The length of the laterals (in this case the horizontal pipes of the expansion loop) depends of course on the distance between the anchors, which are located on the main midway between pairs of laterals. With high pressure steam and distance between anchors of 300 feet, for example, the lateral swings must take up about 7 inches of expansion. If they are 16 feet long, which the writer has used successfully under the conditions stated, the angular swing will be 2.2 degrees (1 degree being equal to about one-sixtieth of the radius, which in this case is the length of the swing, 16 feet). It is well to keep the angular movement within, say, $2\frac{1}{2}$ degrees to avoid too great a turn on the nipples, with likelihood of leakage at the threads.

Fig. 31 shows a simple method of taking up the expansion of mains which may be used in basements and in tunnels of considerable width. Offsets of as little as 3 feet will do the work if placed at sufficiently close intervals. It is somewhat better to drip the main through a full size tee, with drip leg and reducer at the bottom, than through a reducing tee, as with the latter some of the water is likely to be swept up and carried over into the main.

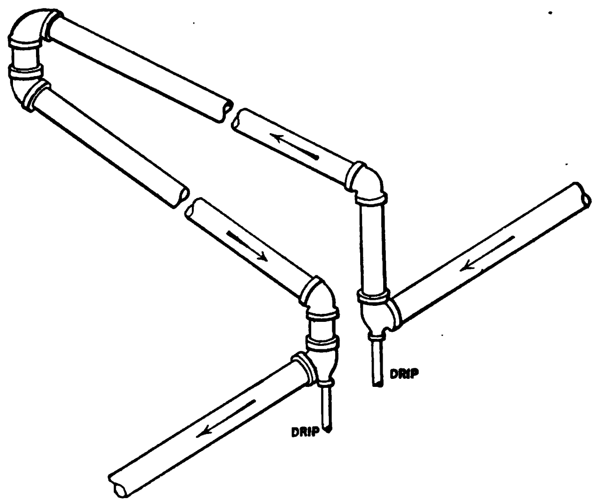


FIG. 30. — Expansion Loop for Mains

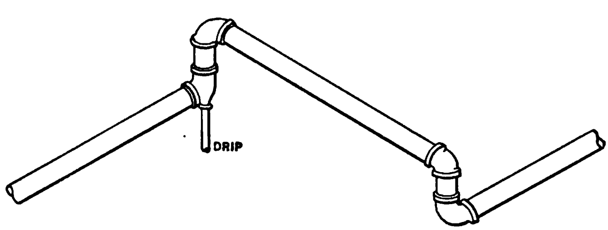


FIG. 31. — Expansion Swivel

Fig. 32 shows the application of a pair of offsets some distance apart in a main.

Fig. 33 shows an arrangement for taking up expansion by means of a U-bend. The offset must be made long enough to provide "spring" sufficient to take up the expansion. If too stiff it is of no use. It often happens, especially in underground work, that the fall must be continuous, no risers and drips being permissible. In such cases the bend illustrated may be used to advantage.

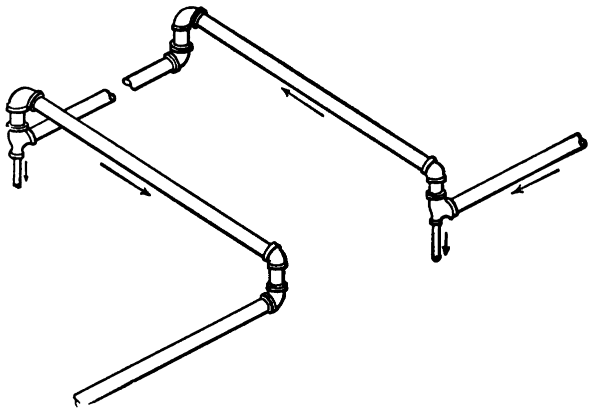


FIG. 32. — Expansion and Drainage Connections

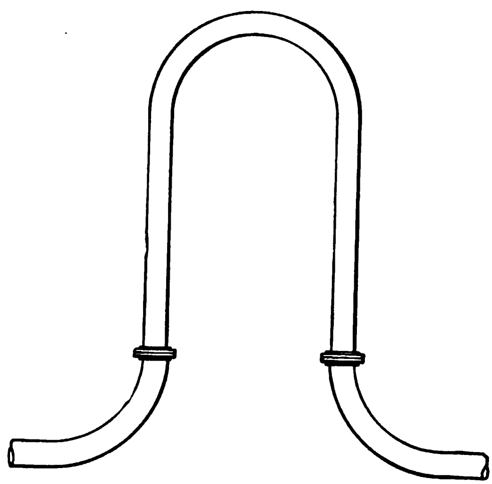


FIG. 33. — Expansion Loop

Fig. 34 shows the proper arrangement of nipples and elbows to provide for the expansion of a horizontal line, the vertical swinging piece being free to move on the nipples. Such an arrangement could be used to advantage in the case of a pipe passing from a basement ceiling to an underground duct.

The ordinary packed expansion joint is shown in Fig. 35. These are used to a limited extent for risers in high buildings and are often found in underground installations. As a rule their use, involving the bother of repacking, can be avoided by utilizing nipples and long swings, as described; the point to be kept in mind in the latter is to avoid too great a turning of nipples and consequent loosening of and leakage at threads.

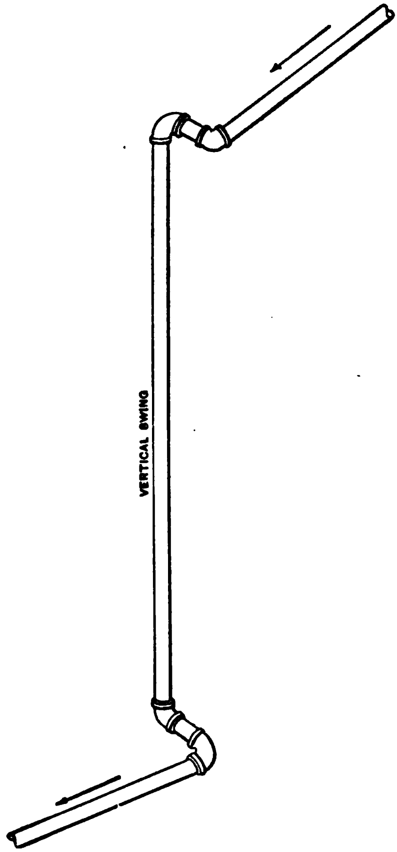


FIG. 34. — Vertical Expansion Swivel

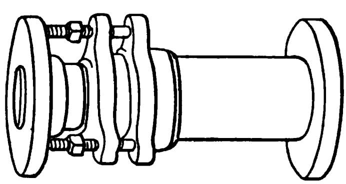


FIG. 35. — Packed Expansion Joint

Fig. 36 illustrates methods of providing for expansion and drainage of pipes entering a building from a tunnel or underground duct. It will be noted that the long horizontal lines swinging on nipples are capable of taking up a great deal of expansion in the main supply and return pipes. The trap connections are also provided with swivels. When buildings some distance apart are connected by underground pipes it is well to take up as much of the expansion as possible in the buildings, thus avoiding expansion joints in inaccessible locations.

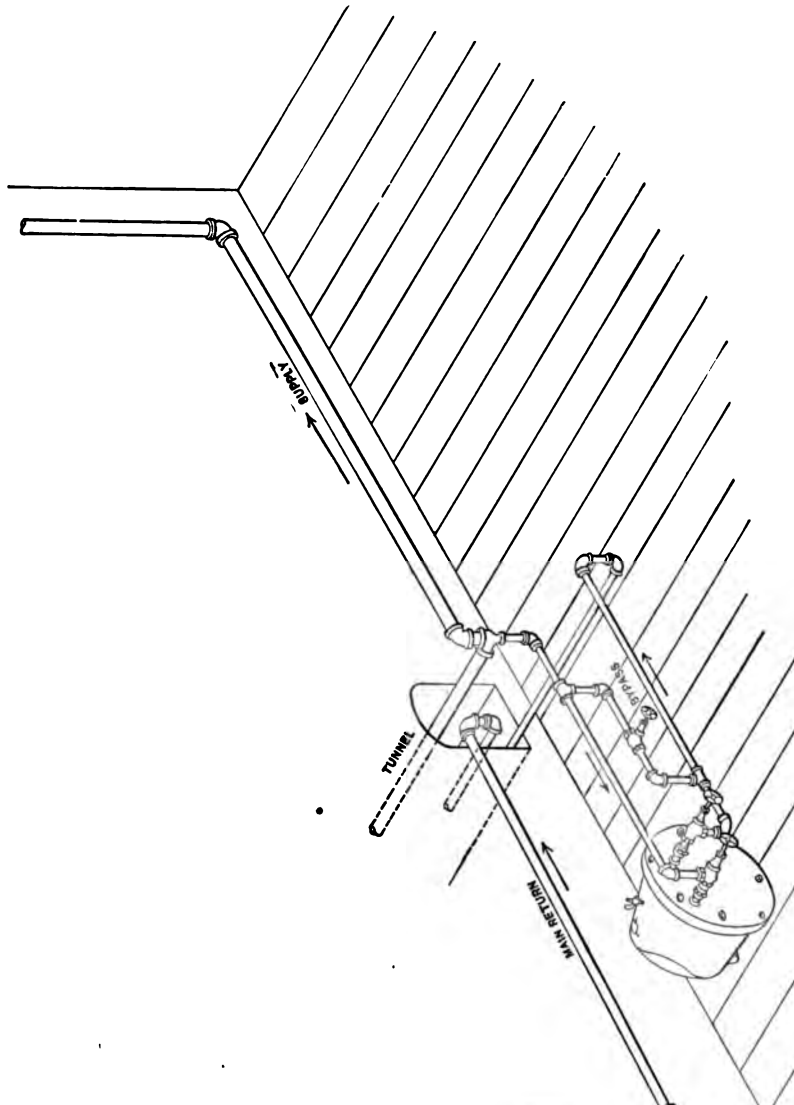


FIG. 36. — Expansion and Drainage at End of Tunnel

Fig. 37 shows a simple method of taking up the expansion of risers by offsetting them below the ceiling every five or six stories. Note the two parallel nipples connecting the fittings at the ends of the horizontal line. The latter must have an ample pitch to avoid a pocket when expansion takes place. The radiator connections are made with proper provision for a movement of the branch.

Where the distance from the floor to the inlet of radiator is not sufficient for the arrangement shown, a corner valve may be used to advantage.

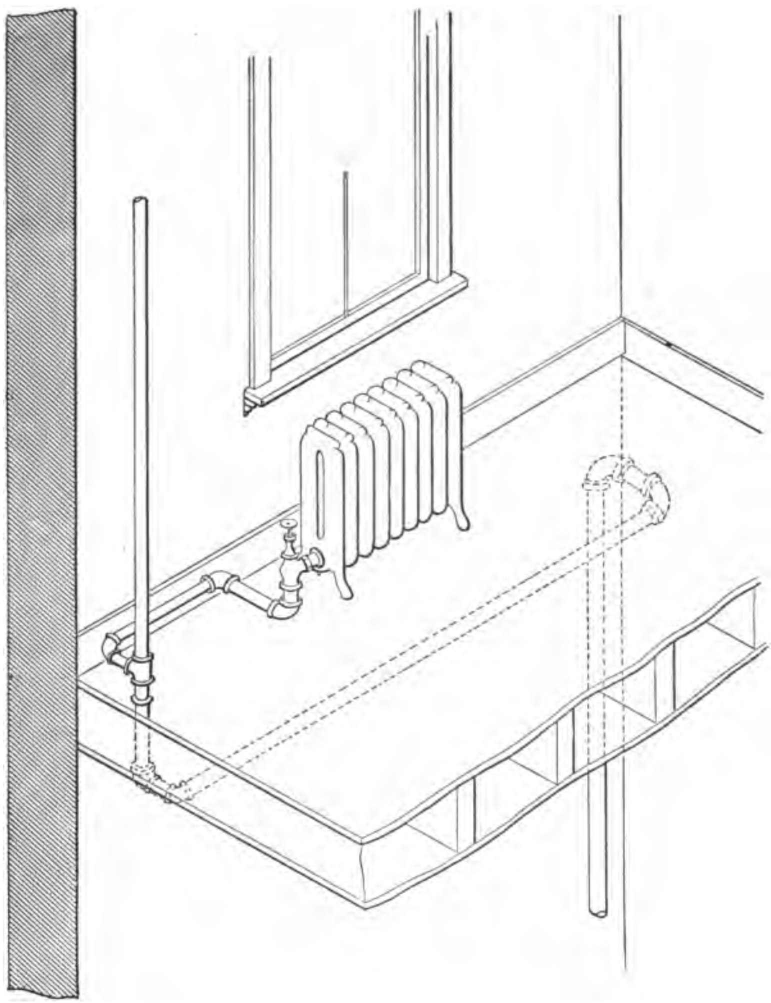


FIG. 37. — Offset Riser Expansion Arrangement

Fig. 38 shows a form of expansion loop made up of elbows, nipples, and swing pieces that may be used with satisfaction in tall buildings, the expansion joints being concealed in pockets in the floors or above a false ceiling. Two of these would be required on each riser in a modern skyscraper of say eighteen stories, the rest of the expansion to be taken up in the attic and in the sub-basement. The risers should be anchored in three places. It is important to anchor the expansion loop to prevent its sagging down and forming a pocket.

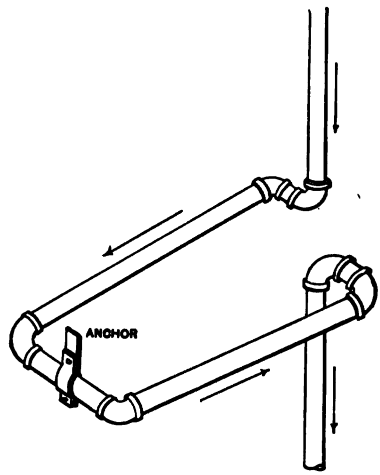


FIG. 38. — Swivel Expansion Arrangement for Risers

Where space permits

Fig. 39 shows a steam radiator placed in front of a window on the first floor. It is well for the sake of appearance to have the top of the radiator an inch or two below the sill. On the lower floor it is better practice to use angle radiator valves connecting with pipes leading from the basement than to connect directly with the risers above the floor level where the "run-outs" would be more or less unsightly. The branch connections in the basement may drain back to the mains if short (see Figs. 40*a* and 40*b*); otherwise they should pitch down away from the main and be dripped to the return at the heel of the riser.

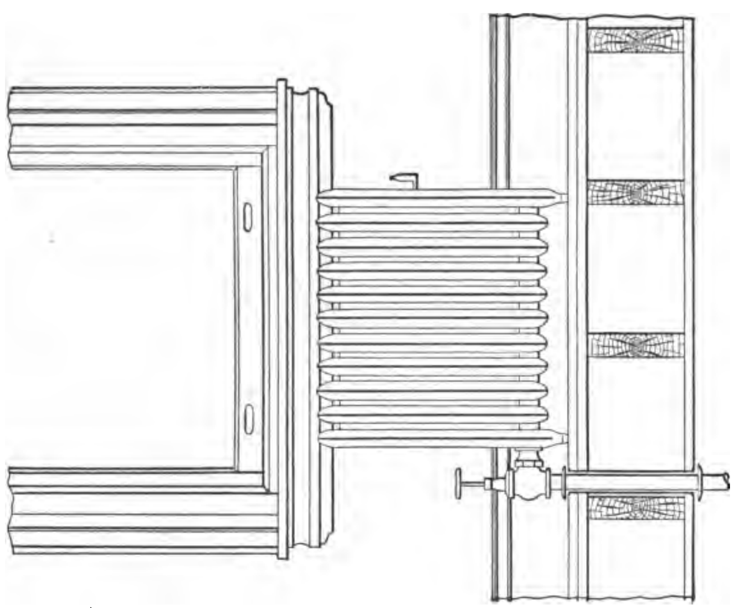


Fig. 39. — Single Pipe Radiator Connection

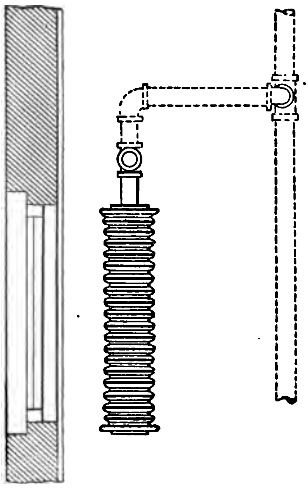


Fig. 40*a*. — Plan, Single Pipe Radiator Connection

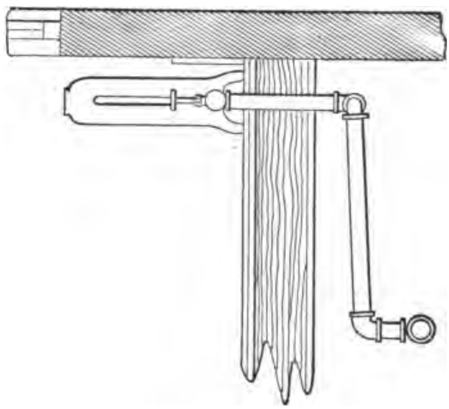


Fig. 40*b*. — End View, Radiator Connection

Fig. 41 shows an arrangement of radiator connections common in offices or rooms that are relatively narrow. By locating the risers as shown, nipples and elbows may be placed in the proper position to act as swivels when the risers expand.

Figs. 42*a* and 42*b* show plan and end view of a radiator with concealed connections and risers. This arrangement may be accomplished with wooden floor construction, but is more difficult in fireproof buildings, since the space between the under side of finished floors and the top of the steel beams is often only about 2½ inches. With covered pipes this gives very little space for expansion. There is no difficulty in such buildings in concealing the risers and bringing the branch connections through plates with elliptical openings attached to the base boards, running the connections along the latter.

Special plates may be procured fitted with slides to provide for expansion.

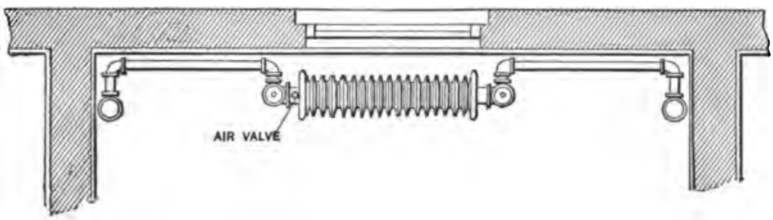


FIG. 41. — Plan, Two-Pipe Radiator Connections Above Floor

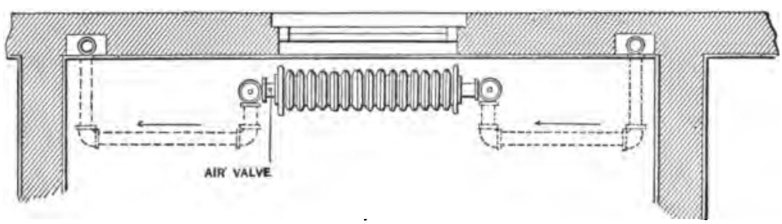


FIG. 42a. — Plan, Two-Pipe Radiator Connections in Floor

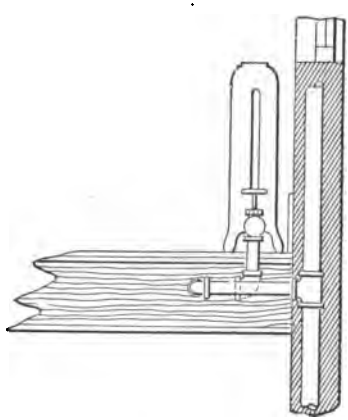


FIG. 42b. — End View Radiator,
Connections Concealed

Concealed risers as in Fig. 43 should always be covered either with sectional covering or with suitable nonconducting material packed in around the pipe, the face of the slot to be covered with metal lathing.

Figs. *44a* and *44b* show a very desirable method of making radiation connection in buildings where the finish is such that the presence of short branch pipes on the ceiling would not be objectionable. Ample provision for the expansion of risers may be made. Note the arrangement of nipples and elbows to secure the proper swing. This method of making connections overcomes the difficulty experienced with radiator connection above the floor, that when a riser anchored midway expands, the tees below the anchor are apt to bring up against the floor, while those above on a high building may raise the branch connection enough to form a pocket. To overcome these troubles radiators have to be raised on boards or pedestals or fitted with extra high legs, in order to secure sufficient pitch to the connections between the radiators and the risers.

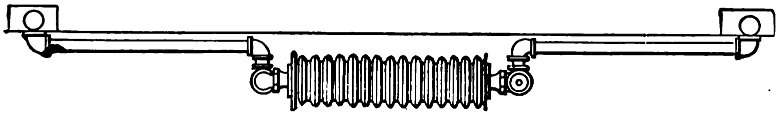


FIG. 43. — Plan, Two-Pipe Radiator Connection, Risers Concealed

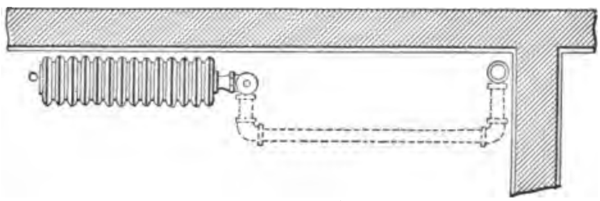


FIG. 44*a*. — Plan, Single Pipe Radiator Connection, Branch Below Ceiling

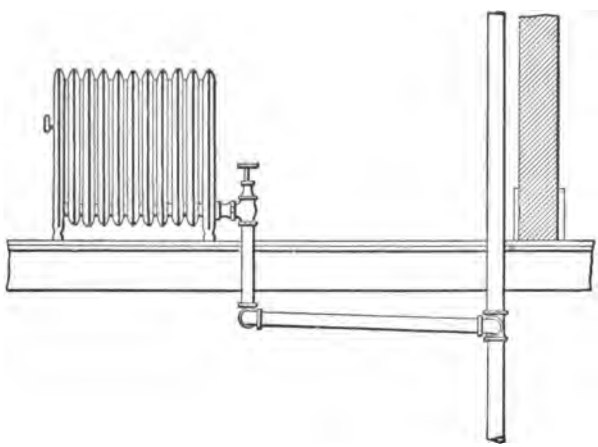


FIG. 44*b*. — Elevation, One-Pipe Radiator Connection

Figs. 45, 46, and 47 show one-pipe radiator connection in office buildings and the like. The method shown in Fig. 46 is preferable, as it provides the freest swing to take up the expansion of the riser.

A corner offset valve is shown connected with a nipple and elbow. This arrangement may be secured with rather wide radiators like the three-column or four-column type, but for narrower radiators either the radiator must be blocked up and an angle valve with nipple connected with an elbow set at 45 degrees be used, or a straightway gate or offset globe valve be used, as shown in Fig. 47, the swing to be provided for by nipples and 45-degree elbows.

Fig. 48 shows a method of connecting a radiator with supply and return risers which must be run close to a wall. While this makes a rather ugly bunch of fittings near each riser they are not very conspicuous along the baseboard of a room, especially if the bronzing harmonizes fairly well with the woodwork.

With this arrangement of fittings expansion can take place without putting too great a strain on fittings, provided, of course, the risers are properly anchored and the branches are not too short.

Fig. 49 shows two-pipe radiator connections, the return being connected directly with the riser without swing or swivel, the spring of the pipe being depended on to allow for the expansion.

The shorter and larger supply connection is shown provided with nipples and elbows to take up expansion in the usual manner.

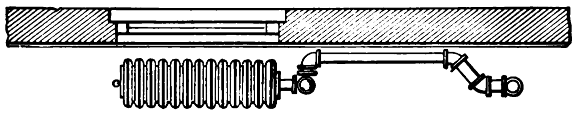


FIG. 45. — One-Pipe Radiator Connection

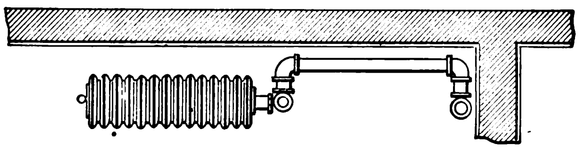


FIG. 46. — One-Pipe Radiator Connection

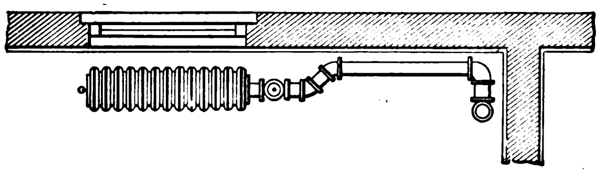


FIG. 47. — One-Pipe Radiator Connection

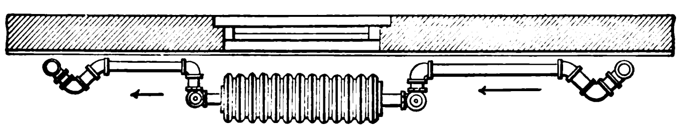


FIG. 48. — Two-Pipe Radiator Connection

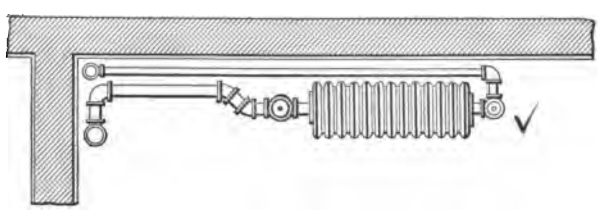


FIG. 49. — Two-Pipe Radiator Connections

Fig. 50 shows a method of making two single pipe radiator connections with one riser. Elliptical plates and slots will be required in the partition to provide for the up and down movements of the branch.

It is far preferable to make the connections as shown than to use a tee at A and make branch connections therefrom with the right-hand radiator, or to express it technically, than to use a "bullhead" tee.

Figs. 51*a* and 51*b* show by plan and elevation a single pipe concealed connection with a radiator and an exposed riser. In certain cases this scheme can be adopted and, of course, presents a neat appearance in the room, except for the riser, which it is assumed cannot, for some reason, be concealed. It must be borne in mind in using exposed risers that as a rule they should be covered, in order that the room temperature may be properly controlled in mild weather.

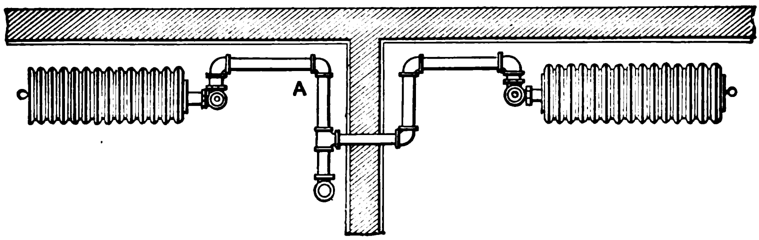


FIG. 50. — Single Pipe Radiator Connections

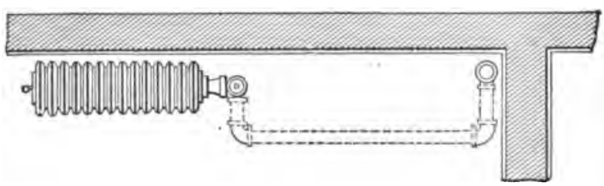


FIG. 51*a*. — One-Pipe Radiator Connection, Branch Concealed

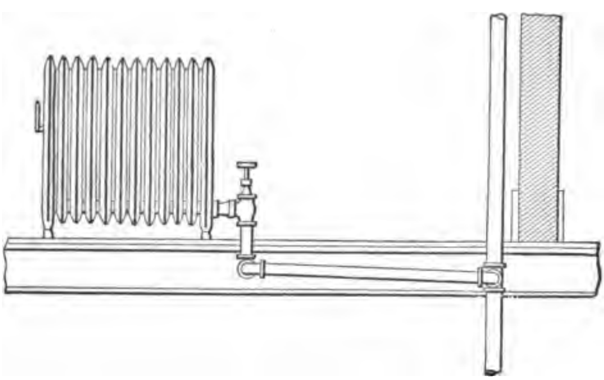


FIG. 51*b*. — Elevation, One-Pipe Radiator Connection

Fig. 52 shows a method of arranging a radiator back of a marble wainscot, with inlet screen at the bottom and outlet register face at the top in the sill. A corner valve is shown with extended spindle to bring the wheel outside. The marble front is, of course, removable. If the wainscot and sill are wood they should be sheathed with asbestos air cell or other nonconducting material not less than ½ in. thick held in place by galvanized iron screwed on.

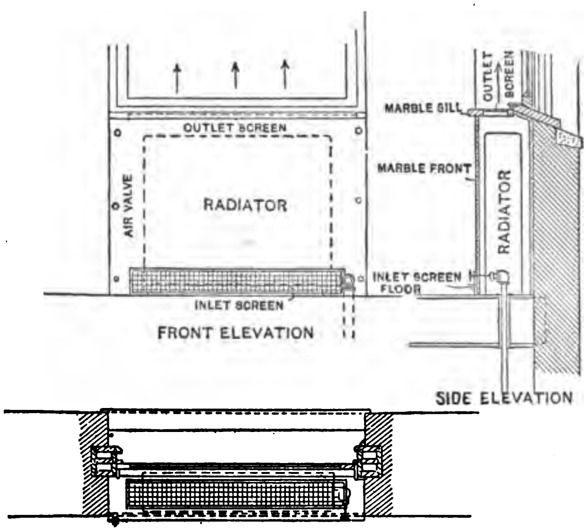


FIG. 52. — Plan, Front, and Side Elevations Concealed Radiator

Figs. 53*a*, 53*b*, and 53*c* show a concealed radiator, the front of the enclosure being arranged to run in grooves, making it easily removable. The top or sill turns up on hinges. If walls are thin or are chiefly of terra cotta the back of the recess should be sheathed with nonconducting material, the top and sides being similarly treated, to protect the woodwork. It is important to make the inlet and outlet openings of ample area. An allowance of $2\frac{1}{2}$ and 3 square inches net register area to each square foot of radiating surface for inlet and outlet respectively gives well proportioned openings.

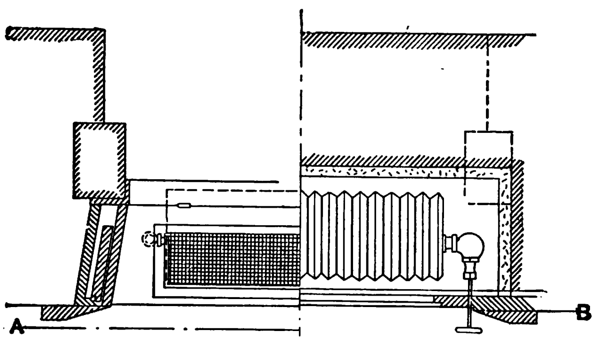


FIG. 53*a*. — Plan, Concealed Radiator

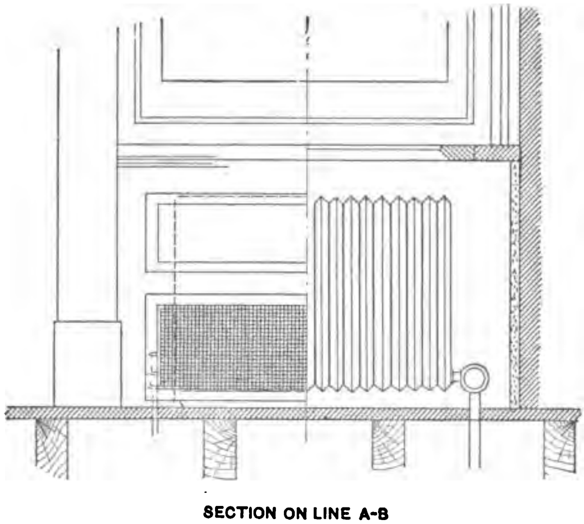


FIG. 53b. — Elevation and Section Concealed Radiator

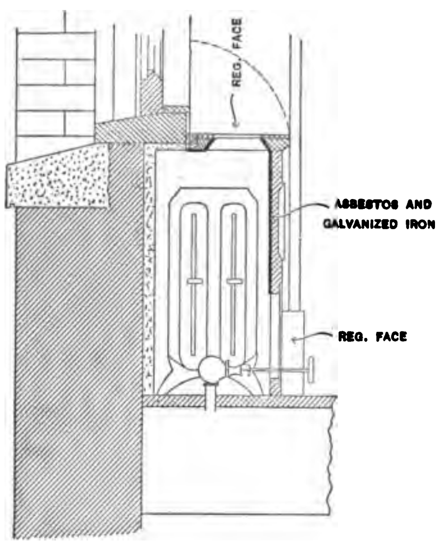


FIG. 53c. — Concealed Radiator Section with Wooden Screen

A method of concealing radiators back of seats is shown in Fig. 54. This treatment is convenient in billiard rooms, reception rooms, and the like, and large seats set back to back in waiting rooms may have radiators concealed between them to advantage. The screens or registers should be proportioned about as stated above. (See p. 70.)

Fig. 55 shows an excellent arrangement of wall radiation in a factory. A uniform distribution of heat is secured and the radiators are out of the way. This arrangement would not be very satisfactory in rooms where benches are located around the walls, since the radiant heat would be objectionable to those working opposite the groups of radiators. About the best arrangement where benches are to be used is to place wall radiators or coils below them, the benches being set out 2 or 3 inches from the wall, giving a passage for the hot air ascending from the radiators. Where persons must be seated at the benches a screen in front of the radiators is recommended, otherwise the heat will be too intense.

It is rarely that windows are spaced so far apart that radiators may be used as shown in Fig. 55, which represents an actual installation.

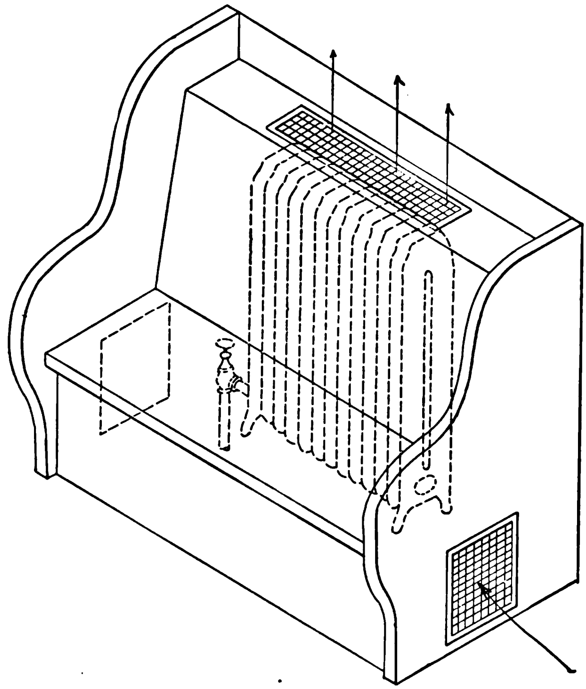


FIG. 54. — Radiator Concealed Behind Seat

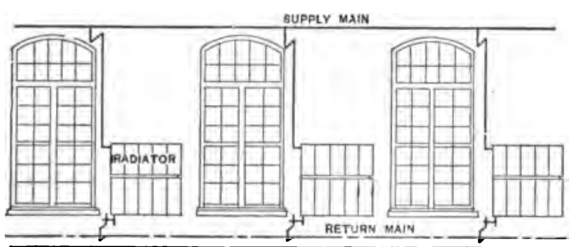
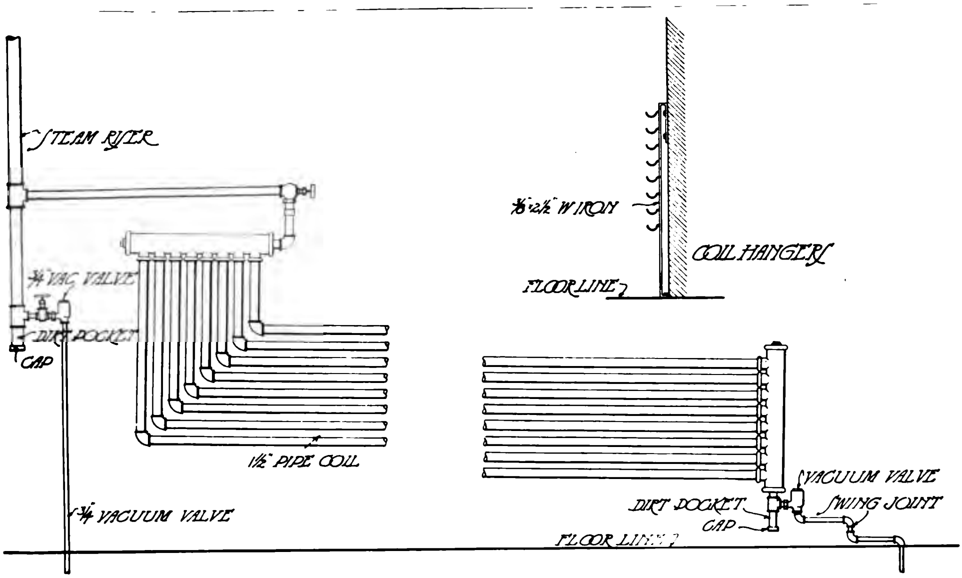


FIG. 55. — Arrangement of Wall Radiation

Fig. 56 shows in plan the arrangement of an ordinary manifold wall coil. Common cast-iron hook plates (Fig. 62) are used to support the long pipes, the short ones near the corner of the room being supported by expansion plates (Fig. 63). Coils of this type are more effective than overhead coils, due to their location. A portion of the heat is, however, lost through the walls. Nevertheless, where there is no objection to locating coils near the floor it is without doubt the best place in the room in which to place them.



TYPICAL PIPE COIL AND CONNECTION

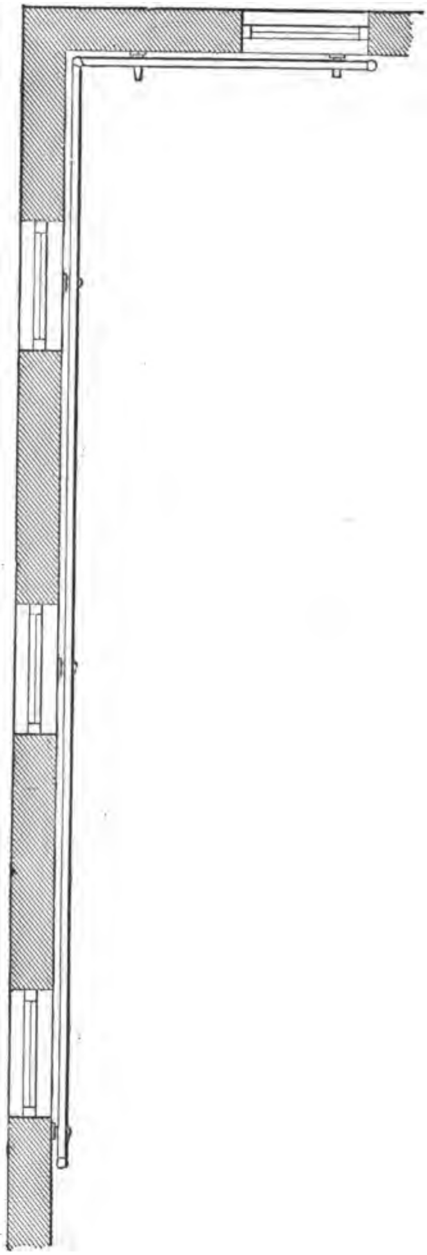


Fig. 56. — Wall Coil

It often happens, due to the length of a mill or to the location of doorways, that ordinary wall coils, similar to Fig. 56, cannot be used throughout. Recourse must then be had to harp or miter coils, illustrated in Fig. 57, or to return bend coils, shown in Fig. 58. Obviously where the length is considerable harp coils should be used, since with return bend coils of unusual length most or all of the steam is condensed before reaching the end, the lower pipes being practically useless. The vertical pipes of a harp coil provide for expansion, and should, as a rule, be made not less than 1 foot in length for every 15 feet of horizontal length of coil. The air valve, shown in Fig. 57, is connected with a $\frac{1}{4}$ inch pipe leading down inside the manifold or branch tee.

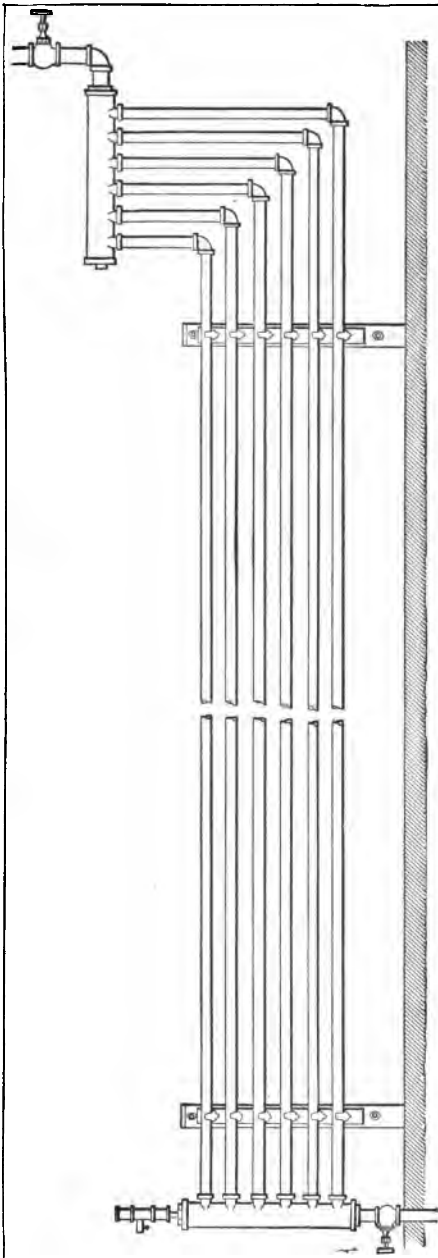


FIG. 57.—Harp or Meter Coil

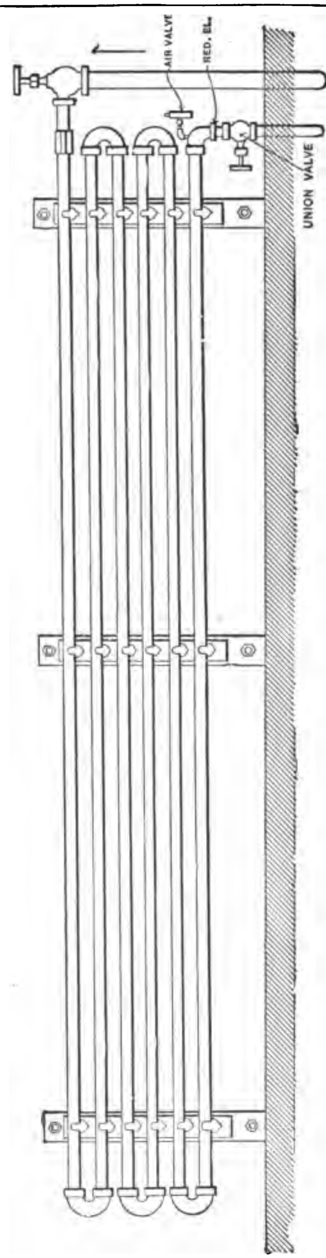


FIG. 58. — Return Bend or Trombone Coil and Connections

Fig. 59 illustrates a wall coil in a schoolroom. The coil is shown broken to save space, but is intended to extend along both walls of the exposed sides of the room. A diaphragm valve in connection with a temperature control system is shown at the left, the return being carried independently to the basement, where a check valve is placed below the water line. These coils are chiefly used in connection with a fan system of tempered air supply, the coils preventing down drafts along the windows and tending to equalize the temperature of the room.

Steam is kept on the coils at night when the fan system is shut down, giving direct heating, the least expensive of any.

The coil near the return header is intended to be supported on expansion plates. (Fig. 63.)

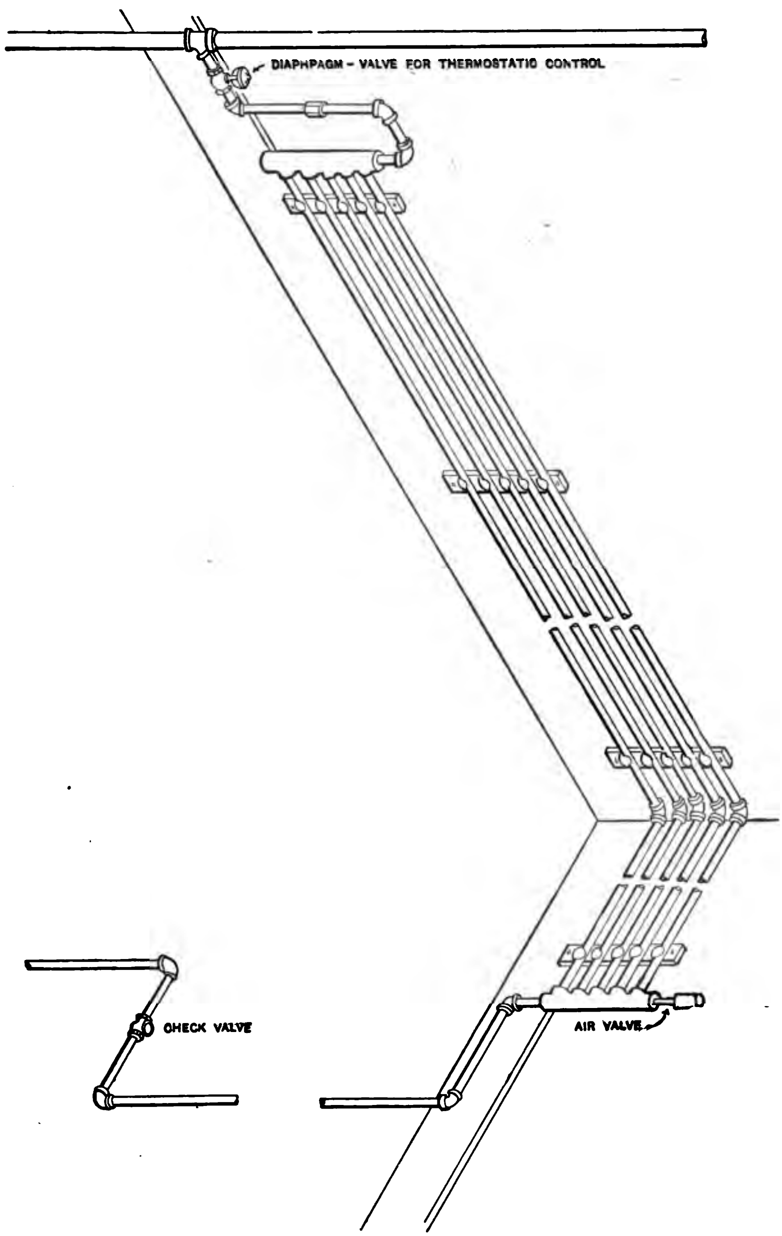


Fig. 59. — Manifold Wall Coil and Connections

Fig. 60 represents an ordinary miter coil used in overhead heating. These coils are generally located not less than 9 or 10 feet from the floor and 3 to 4 feet from the outside walls. If much nearer the floor than the distance stated the radiant heat is uncomfortable to persons working beneath them, and if placed too close to the outer walls the circulation is retarded. The success of this type of heating depends on the cooling action of the glass and walls producing a downward current combined with the upward current produced by the heat of the coils.

By these two forces the warm air is circulated along the outer walls from ceiling to floor. When properly installed this system gives good results, even when there are no belts or moving machinery to stir up the air. (The supports shown under short pipes near the elbows are unnecessary.)

The air valve should be connected with a $\frac{1}{4}$-inch pipe extending inside the header about to the middle.

For very long coils a bleeder with valve through which the air may be blown out is advisable.

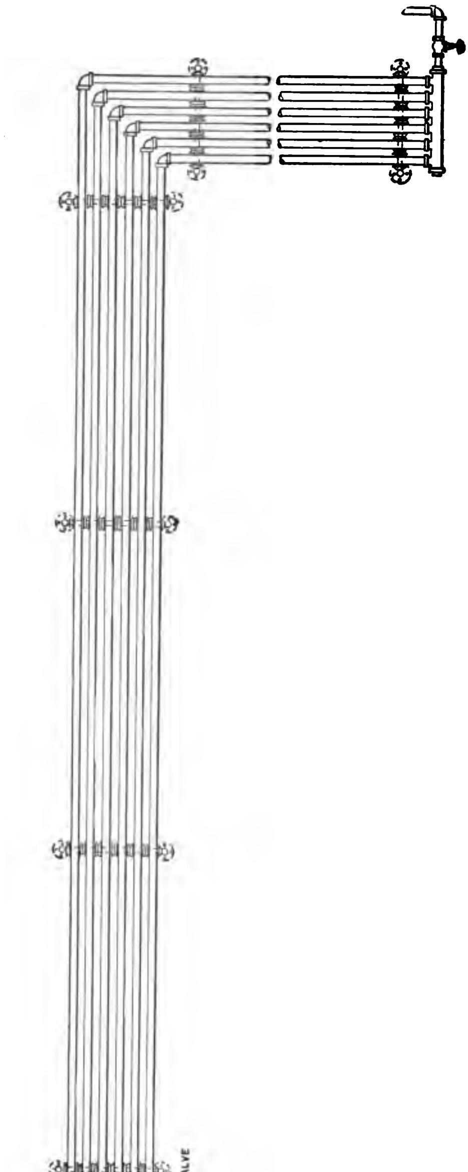


FIG. 60. — Overhead Coil

Fig. 61 shows a convenient method of connecting a return-bend coil with a single pipe system. The check valve insures the heating of the coil through the supply valve only, preventing any backing up of steam or water hammer.

Figs. 62 and 63 show hook plates and expansion plates, the latter used where the movement of the pipes is other than longitudinal. Expansion bolts should be used to hold the hook plates against the wall, wooden battens being placed between the wall and hook plates as shown.

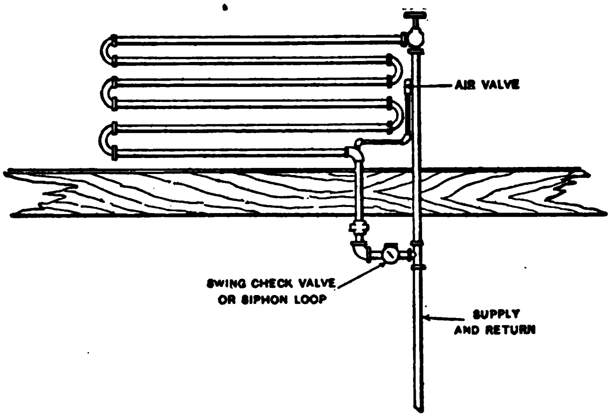


FIG. 61. — One-Pipe Coil Connection with Check Valve as Return

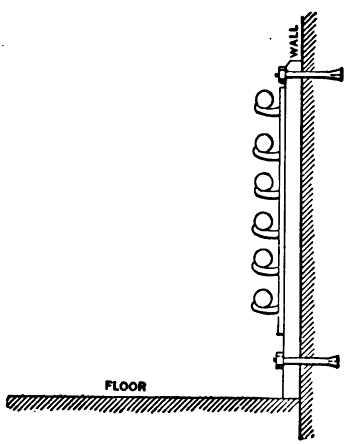


FIG. 62. — Hook Plates

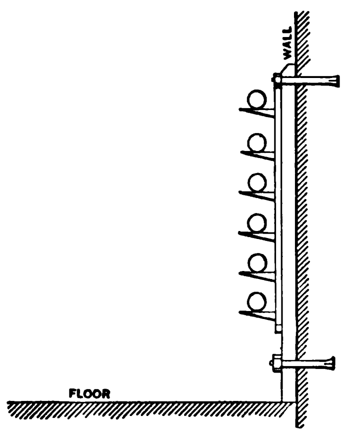


FIG. 63. — Expansion Plates

Fig. 64 shows a somewhat unusual hanger for wall coils, these hangers being made of punched bar-iron suspended from eye-bolts set in the wall.

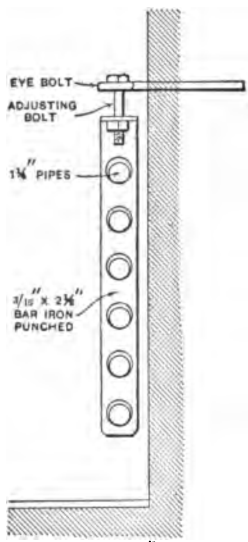


FIG. 64. — Support for Wall Coil

Fig. 68 illustrates a method of hanging overhead coils to prevent the sagging of the rods supporting the rolls on which the pipes rest.

Fig. 69 shows a convenient cast-iron support for short bolt passing through the vertical eye-bolt, holding these firmly in place. With this type of hanger a single rod takes the place of two, as shown in Figs. 65, 66, and 67.

Hangers or supports for coils are placed 10 to 12 feet apart. Several types are here shown.

Overhead coils should be hung with $\frac{1}{2}$-in. rods 10 feet on centers. The horizontal rods which carry the pipe rolls should be $\frac{9}{16}$-in. diameter steel to avoid sag where the coils have more than 6 lines of pipe. The hanging rods may have an eye in each end and be fastened at top with $\frac{1}{2}$-in. lag screw in side of beam or may have gimlet point at upper end. The latter looks neater and permits an adjustment. Gimlet point should enter wood about 3 in. Where beams are not present a casting to hold $\frac{1}{2}$-in. nut may be used. Casting to be screwed up with $\frac{1}{2}$-in. or $\frac{3}{8}$-in. lag screws.

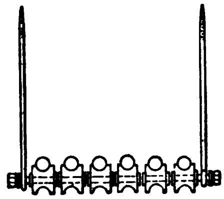


FIG. 65

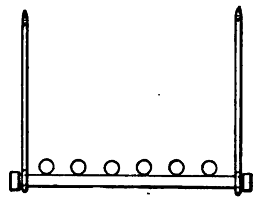


FIG. 66

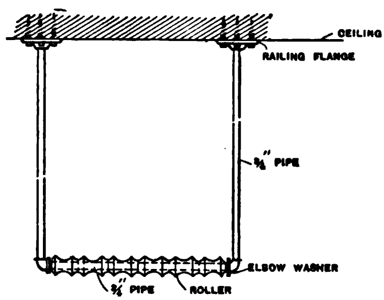


FIG. 67
Hangers for Overhead Coils

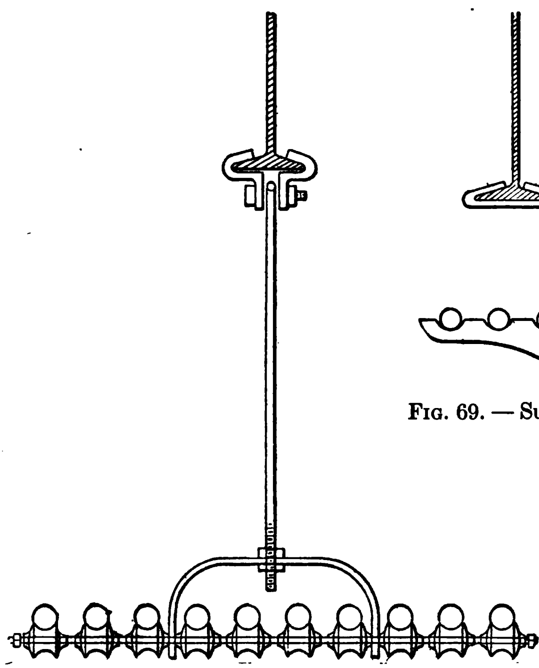


FIG. 68. — Support for Overhead Coil

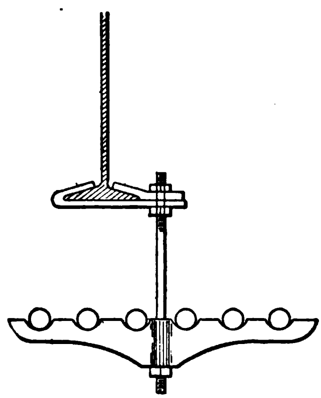


FIG. 69. — Support for Overhead Coil

Figs. 70*a* and 70*b* show one method employed for anchoring a riser to an I-beam.

Figs. 71*a* and 71*b* illustrate a method of anchoring a steam main to a wall. The smaller the angle between the wall and the irons the more rigid the anchorage.

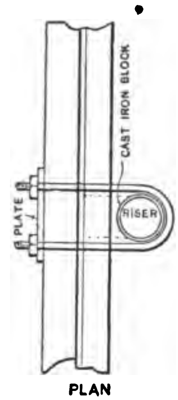


FIG. 70*a*

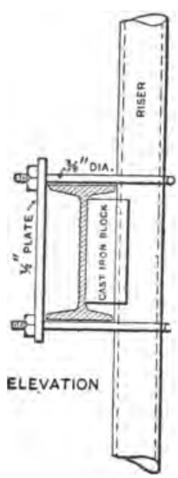


FIG. 70*b*
Plan and Elevation of Anchor for Riser

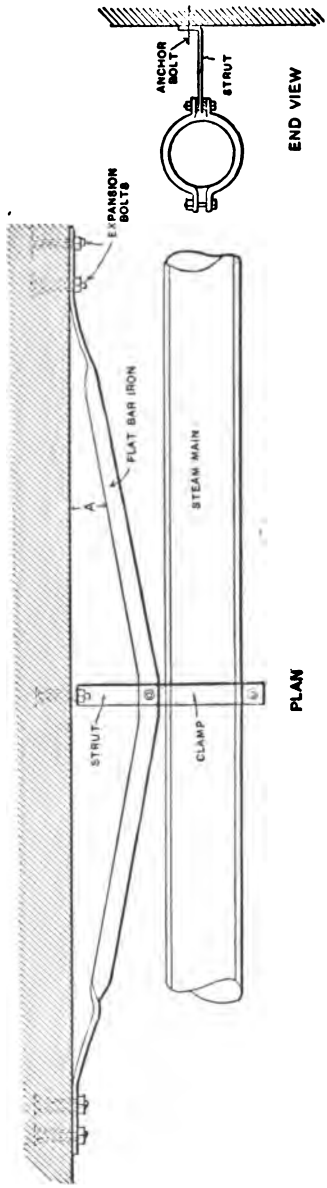


FIG. 71*b*

FIG. 71*a*
Plan and End View of Anchor for Steam Main

Fig. 72 shows a simple hanger, which by giving the vertical bar a quarter turn may be used when the beam and the pipes are at right angles.

Fig. 73 shows a hanger somewhat similar to the one illustrated by Fig. 72, the principal difference being the detail of construction of the beam clamp.

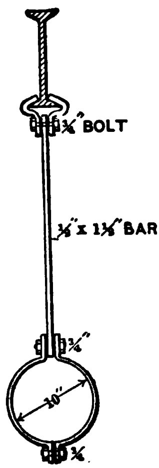


FIG. 72

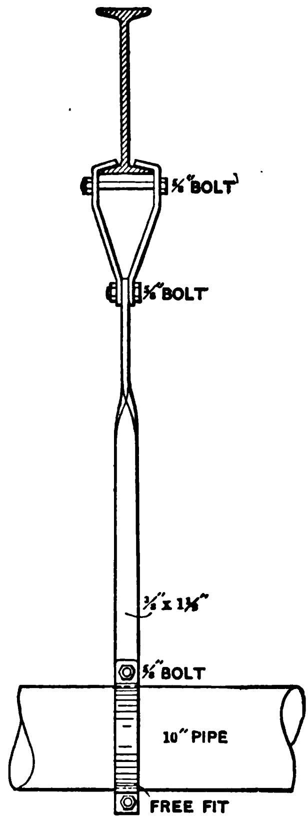


FIG. 73

A Variety of Pipe Hangers

Figs. 74*a* and 74*b* show two views of a very simple hanger that may sometimes be used when the pipe is to be run at right angles to the beams. This form serves very well for hanging pipes from trusses, but is of little use when the nuts are to be covered by flooring, since this renders the hanger incapable of adjustment.

Fig. 75 shows a hanger possessing certain advantages. The clamp at the top is made of two pieces, having eyes through which the vertical bolt passes.

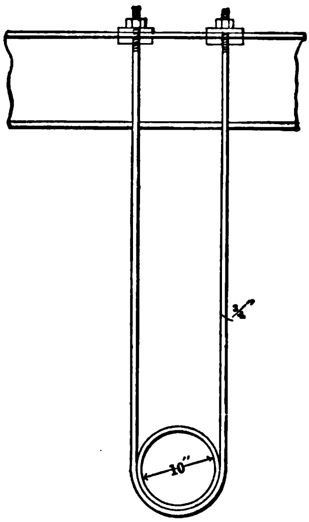


FIG. 74a

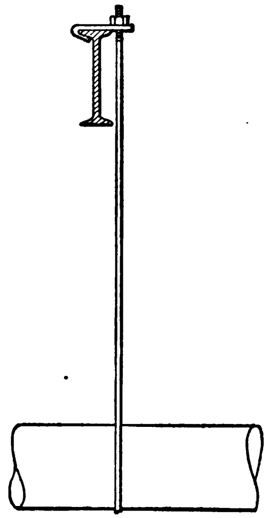


FIG. 74b

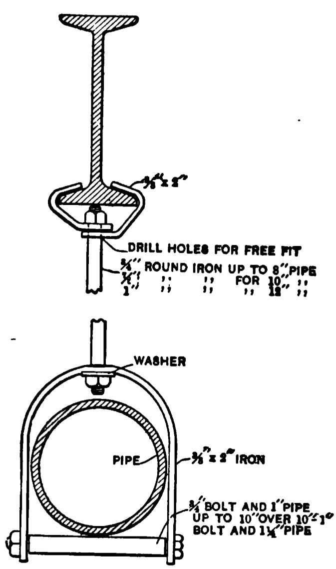


FIG. 75

Figs. 76*a* and 76*b* show a hanger neat in design and of pleasing appearance when in place, the necessary adjustment being secured by means of the turnbuckle.

Fig. 77, from the *Valve World*, shows a type of hanger used at the Calumet & Hecla Mining Company, Calumet, Mich., for carrying a large steam main.

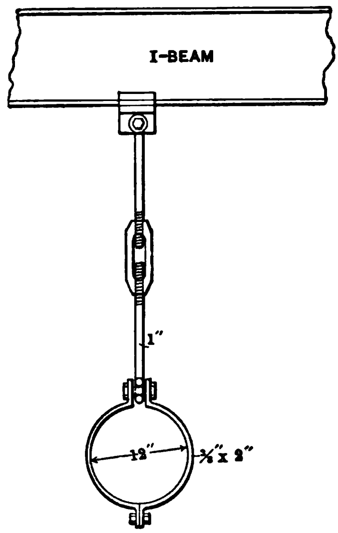


FIG. 76a

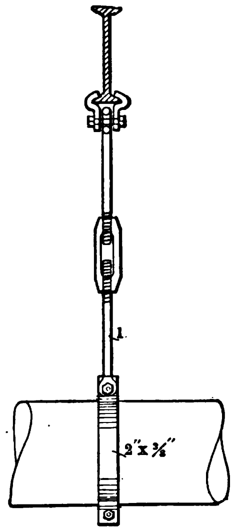


FIG. 76b

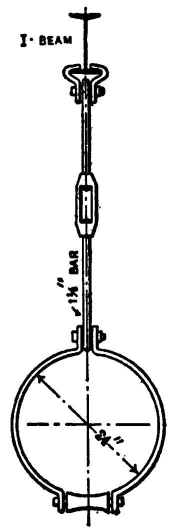


FIG. 77

Figs. 78 and 79 show hangers for small and large pipes. Hangers of these types are not infrequently used in United States Government buildings. The ones shown are for use in connection with concrete floors, but by substituting beam clamps for the plates they make equally good I-beam hangers.

Fig. 80 shows a hanger similar to Fig. 79, but designed to clamp to the pipe.

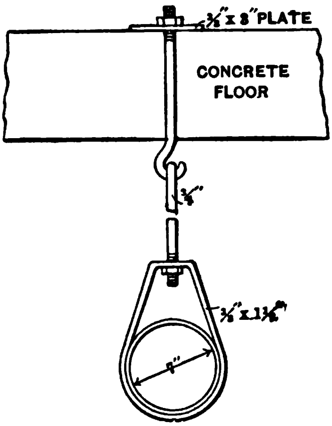


Fig. 78

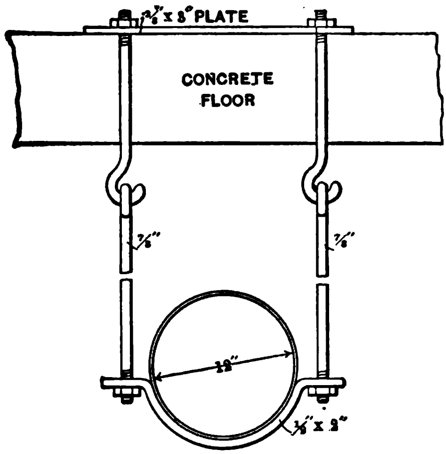


Fig. 79

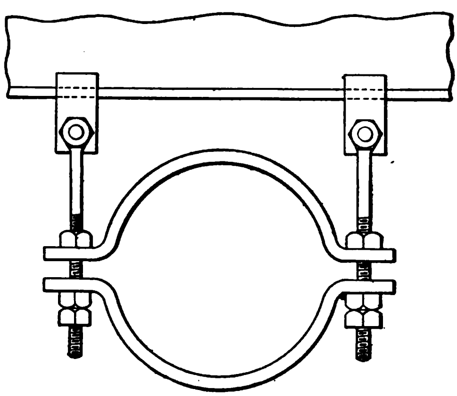


Fig. 80

The direct-indirect or semidirect flue radiator with box base shown in Fig. 81 and the wall box shown in Fig. 82 are combined in Fig. 83.

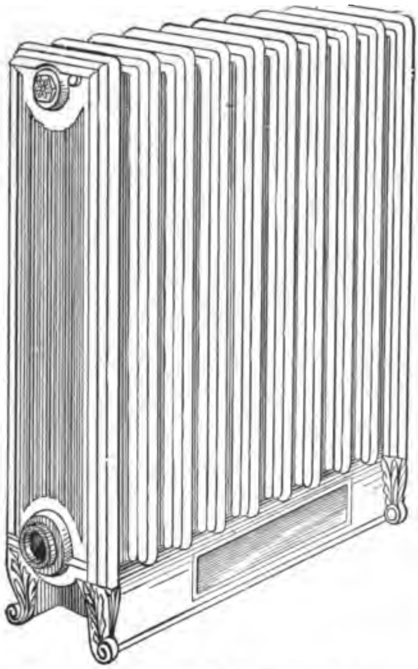


FIG. 81. — Direct-Indirect Radiator, Perspective

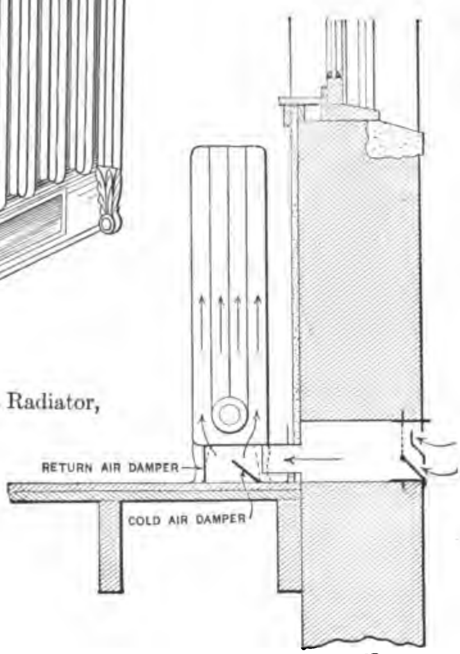


FIG. 83. — Direct-Indirect Radiator, Section

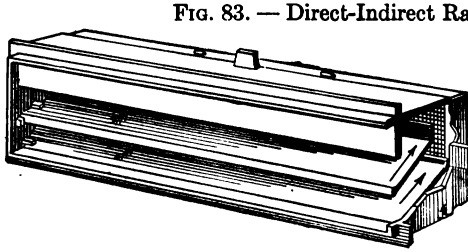


FIG. 82. — Wall Box

Fig. 84*a* shows a better arrangement, the wall box being placed close to the under side of a sill, the projection of which casts a shadow which renders the box inconspicuous. The double right angle turn serves as a wind break and makes the flow of air through the radiator more uniform. The double dampers are linked, so that one must be open when the other is closed. At least 25 per cent. more surface must be allowed with this type of radiation than when direct radiation is used. Double dampers are provided in the box base, arranged to shut off the cold air inlet when air is being returned from the room, and *vice versa*. A highly desirable modification of the arrangement shown in Fig. 84*a* is to have an extra thick wooden sill through which the air enters, passing through a screen or grating. This arrangement shown in Fig. 84*b* does away with wall openings and wall boxes.

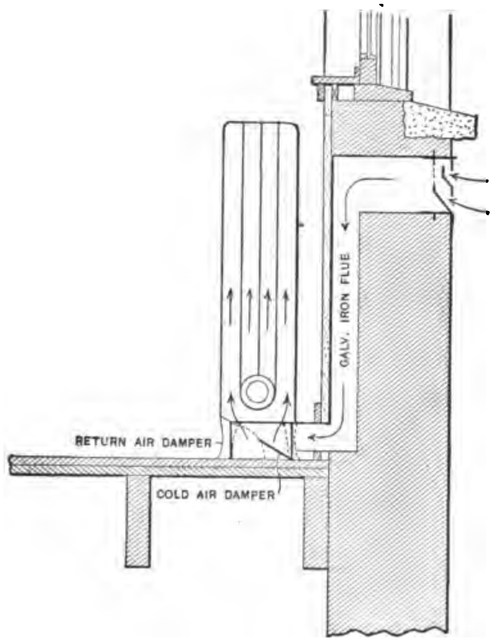


FIG. 84*a*. — Section, Direct-Indirect Radiator with Drop Flue

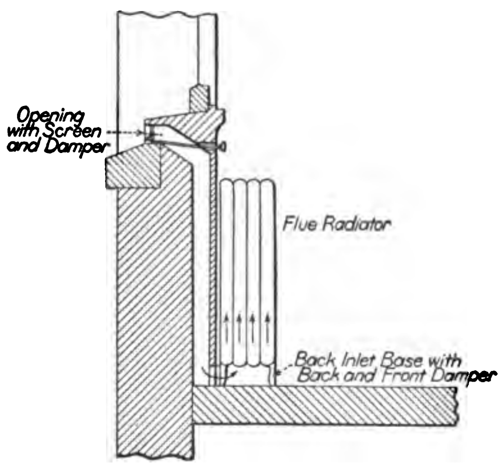


FIG. 84*b*. — Arrangement of Direct-Indirect Radiator with Sill Inlet for Fresh Air

Fig. 85 shows a simple arrangement of a stack or bench of indirect radiators supplied from a cold-air duct which may well run through the cellar, with an inlet at each end fitted with check valves arranged to admit air but to prevent back draft. The top of the casing is of $\frac{7}{8}$-in. boards lined with asbestos and tin. The sides and bottom are of galvanized iron, with joints designed to provide for readily removing the casing. Slides are provided as indicated. The flue should have back and sides protected with asbestos air-cell covering not less than $\frac{1}{2}$-in. thick.

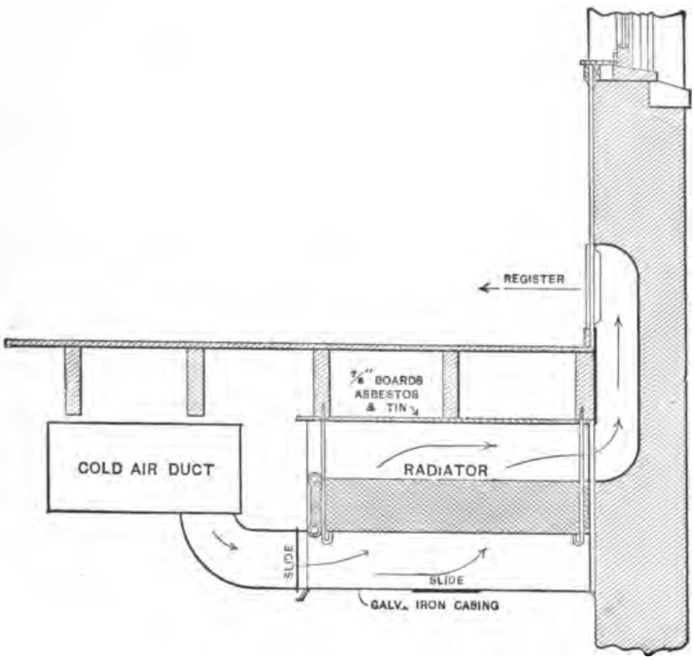


Fig. 85. — Indirect Radiator with Ducts

Fig. 86 shows a stack of indirect radiators with a direct cold-air inlet through the wall below the casing.

Fig. 87 shows a stack of indirects with cold-air connection, by-pass, mixing damper and operating device.

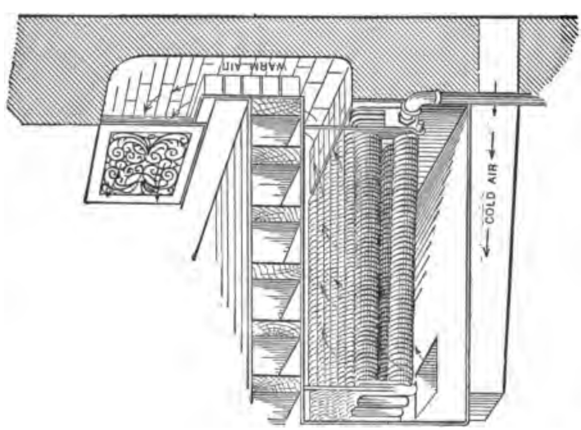


FIG. 86. — Indirect Radiator with Inlet and Outlet Connections for Air

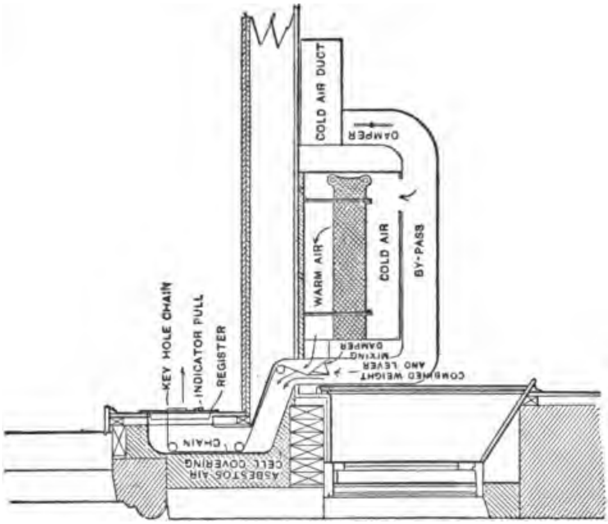


FIG. 87. — Indirect Radiator with Ducts and Mixing Damper

Figs. 88*a* and 88*b* show a plan and sectional elevation of benches or stacks of indirect radiators as arranged for schoolhouse heating. Fresh air enters the chamber through the opening with arrow, or at night, when this opening is closed, the air is rotated through the building and re-enters the air chamber through an opening in the first floor, this opening being closed during the day by a tight fitting damper. The air passes from chamber C up through the radiators to the flue, unless a portion of it is allowed to pass directly to the flues by the raising of the mixing damper to position shown by dotted line. This damper is controlled by the teacher by means of the chain, &c., indicated. The heating chamber is inclosed in brick in the corner of the basement rooms, the top being plastered on metal lath and a tight joint made with the walls. The radiators are connected in groups to give the proper control of the temperature, the returns being kept above the water line until they pass through the walls of the chamber.

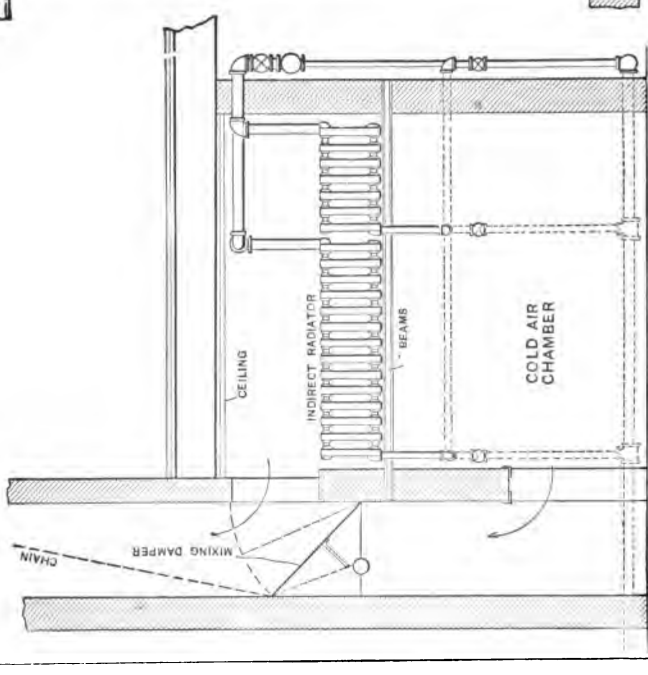


FIG. 88a. — Section, Indirect Radiation and Connections

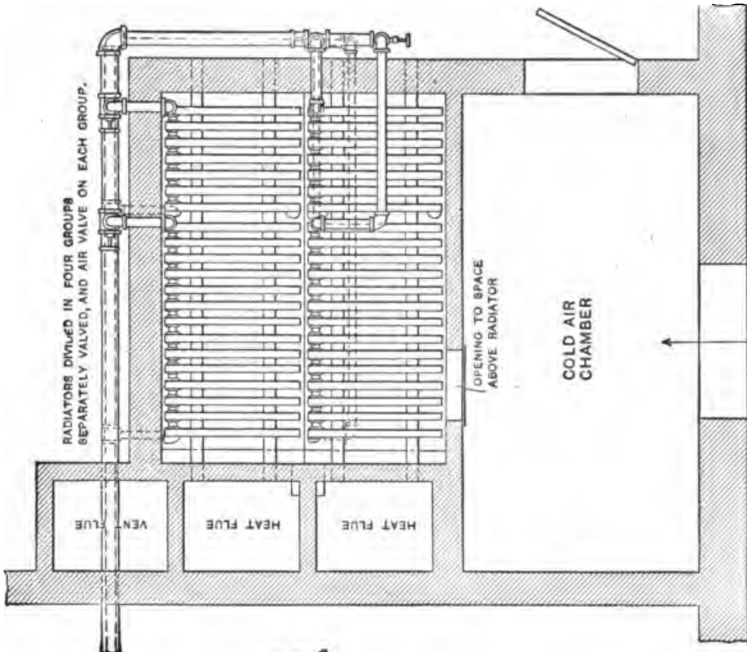


FIG. 88b. — Plan, Indirect Radiation in Brick Chamber

One of the most common types of heaters used in connection with hot-blast apparatus, so called, is indicated in Figs. 89 and 90. The sections are connected by flanged headers with gaskets between them. Bases like those shown in Fig. 90 are used when the heater is to be divided into not more than two groups, these being separated by a blank flange, the steam and return connections being made at each end.

When sections independently connected are desired, bases of the pattern shown in Fig. 91 are frequently used. These bases are tapped at the ends, both supply and return connections being separately valved.

It is especially important when using diaphragm valves in connection with a system of temperature regulation to place them at the highest point in the piping, so that water cannot collect above them, to be discharged in a slug when the valve suddenly opens. A corresponding diaphragm valve should be placed in each return. They are more to be depended on than check valves.

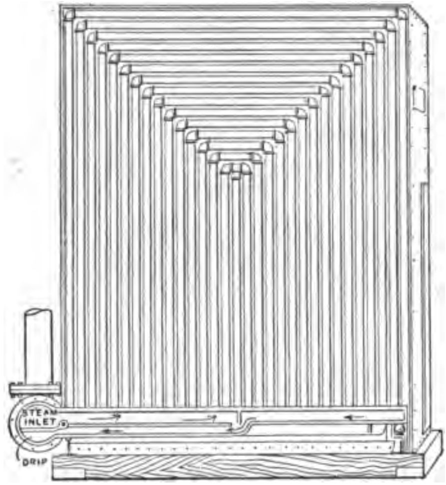


Fig. 89. — Front View Heater Section

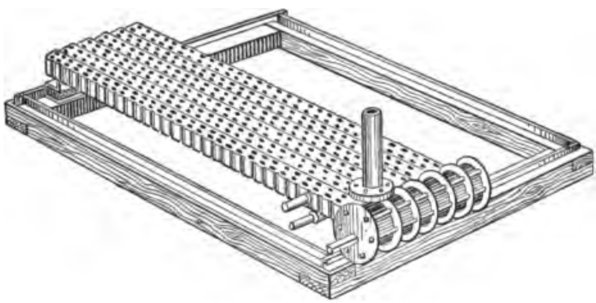


Fig. 90. — Perspective, Heater Bases and Heater

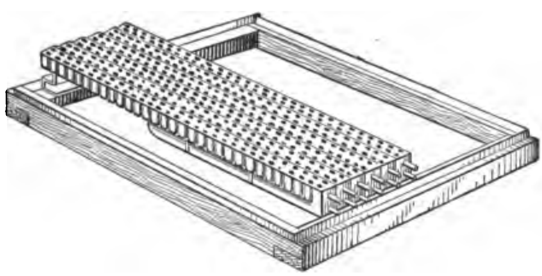


Fig. 91. — Perspective View Independently Connected Heater Bases

Fig. 92 shows a typical arrangement of heater connections.

Note the supply header with drip.

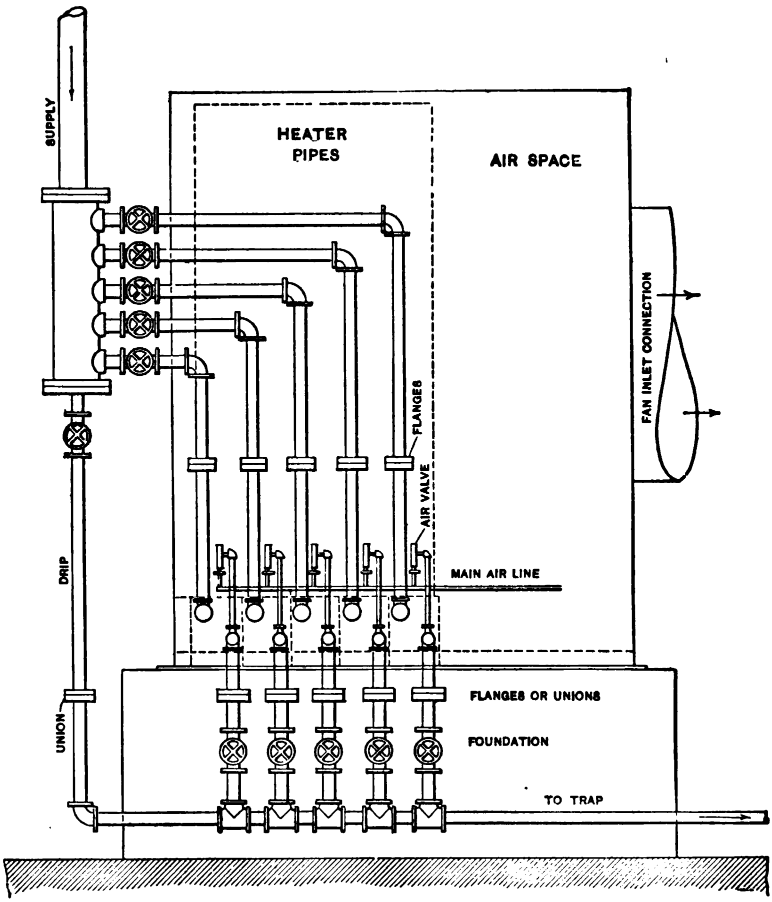


FIG. 92. — Elevation, Hotblast Heater Connections

Figs. 94 and 95 show side and end views of supply, return and bleed connections with a type of heater commonly used in which the vertical pipes are connected at the top by return bends. See Fig. 93. Much of the condensation in the pipes on the supply side of the return bends is carried over them by the velocity of the steam and escapes through the return pipe; the bleeder, marked drip, takes that portion of the condensation that collects in the supply side of the cast iron base. Each bleeder is arranged with a siphon loop with a plugged tee for the removal of any sediment. This siphon discharges into the main return from each section above the valve.

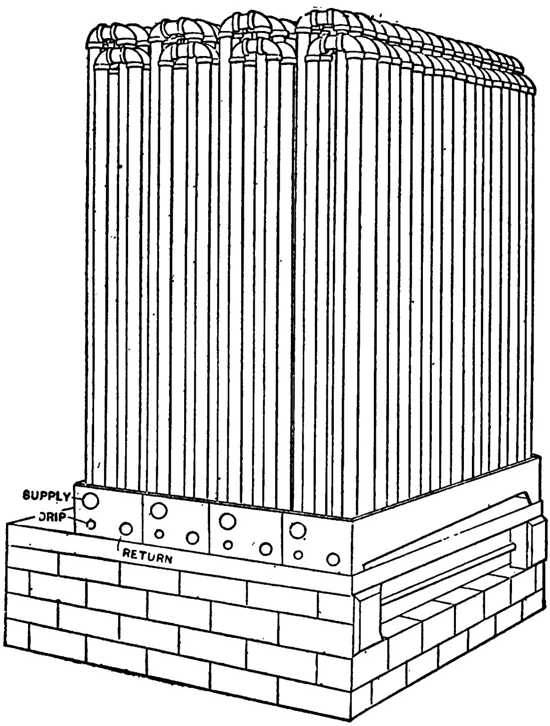


FIG. 93. — Return Bend Pattern Heater Sections

An automatic air valve with air line connection is indicated for each return. To remove air quickly from a heater a valved branch discharging out board should be connected with the main return. When the heater is not divided in groups separately valved the piping is much simpler, only single supply, return, and air vent connections being required.

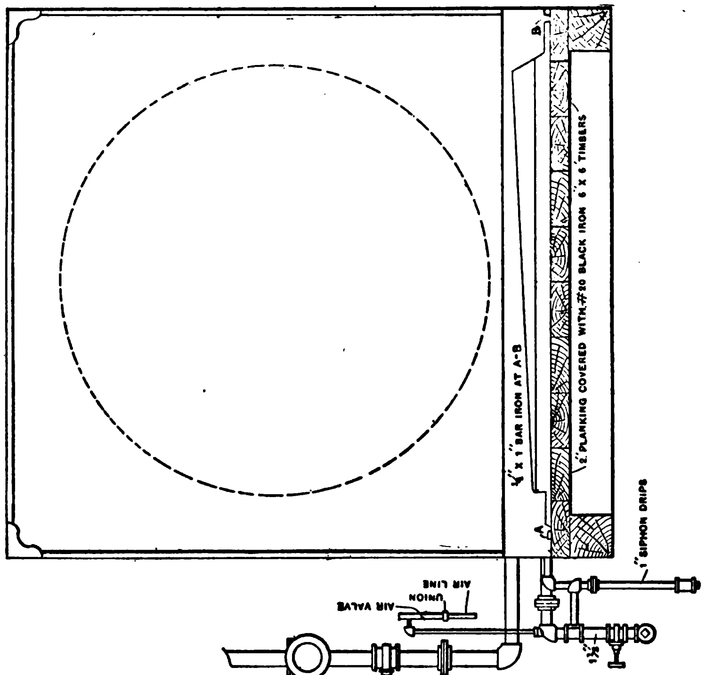


Fig. 95. — End Elevation of Heater and Connections

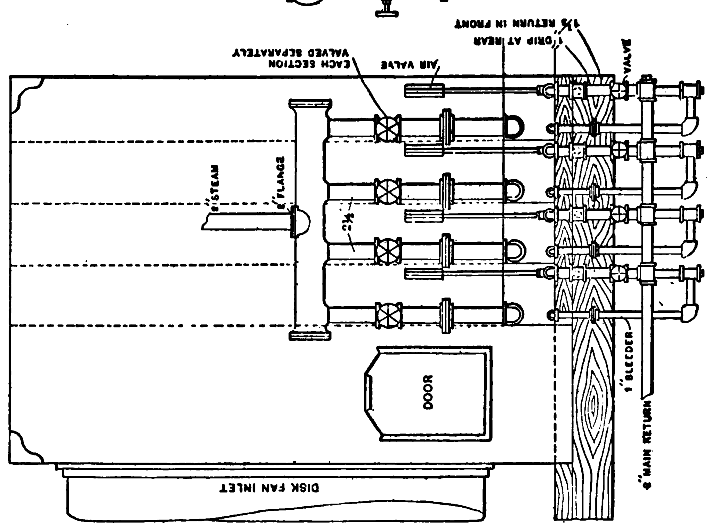


Fig. 94. — Side Elevation of Heater and Connections

Fig. 96 illustrates a type of heater that may be used to advantage in certain locations. By making the horizonal pipes longer a heater of this type may be constructed having a large surface and yet occupying little height, a valuable feature in case gravity return to boilers is desired. The space not occupied by pipes is to be stopped off with sheet iron, or may serve as a cold air by-pass controlled by dampers. This type of heater is suited to the circulation of hot water.

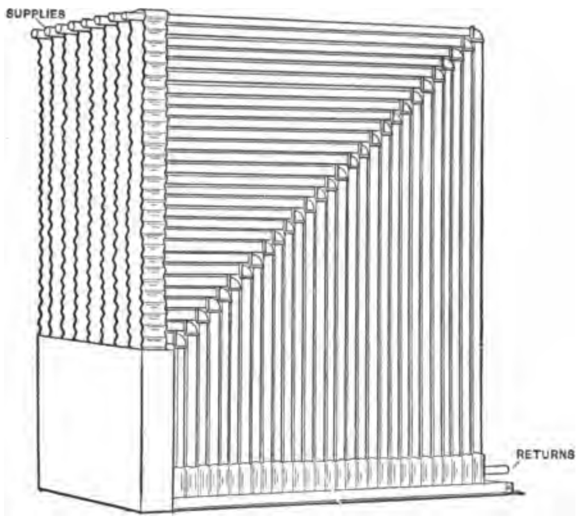


Fig. 96. — Miter Coils, Hot Blast Heaters

Fig. 97 shows a type of radiation commonly used with fan systems, cast iron sections which may be easily handled being made up into large heaters taking the place of pipe coils.

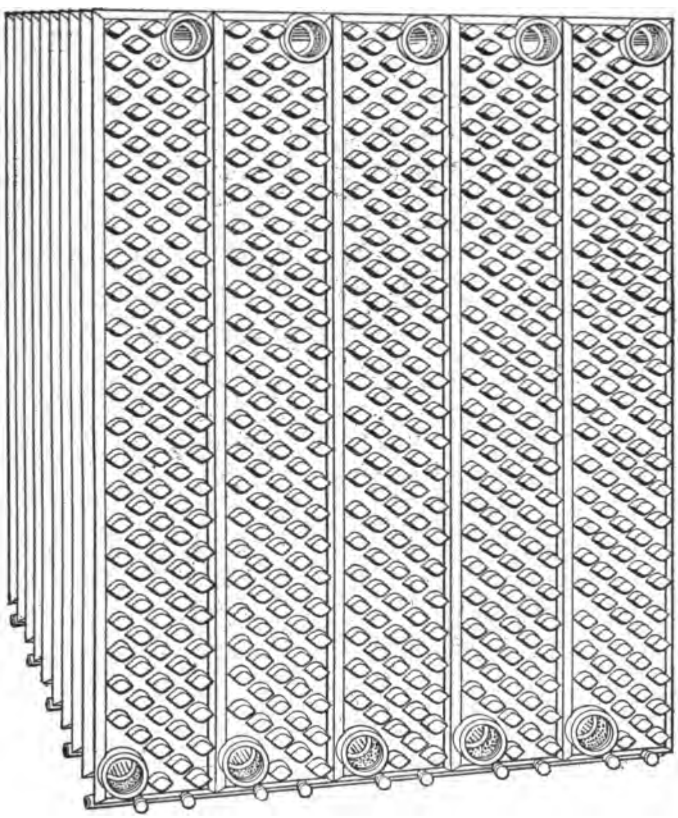


FIG. 97.—Cast Iron Vento Radiators for Fan Systems

Fig. 99 represents a return bend coil commonly used as a supplementary heater in ducts or at the base of flues. Such coils should be divided in sections to afford proper control of the temperature. It is well to divide them in unequal parts, for example, a coil 12 pipes deep may well be divided in two sections of four and eight pipes, thus giving a better control of temperature by cutting out one or the other of these sections than if the heater were equally divided. When thermostatic control is used the diaphragm valve may well be placed outside the hand valves controlling the sections, the shallow coil being used in mild weather, the deeper one in colder weather, and both sections when the outside temperature is low.

Heaters of the type described may be suspended by beam clamps attached to vertical pieces of bar iron properly drilled for bolts passing through pieces of 1-in. pipe to give stiffness. It is well to give the pipes a slight pitch, say $\frac{1}{8}$ in. per foot, to make sure of the ready removal of condensation. The free area for the passage of air through such a heater may be taken roughly at 40 to 50 per cent. of the cross sectional area of the casing. The area of the passage for air should always be computed and should be 10 to 25 per cent. in excess of the area of the duct connected with the heater to allow for the additional resistance due to the pipes. It is often necessary to use more pipe than would otherwise be required, merely to secure the proper air passage.

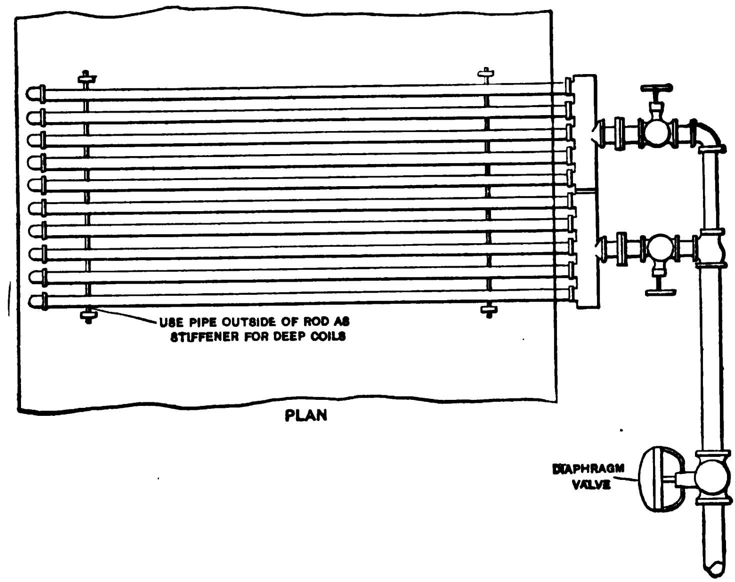


FIG. 98. — Plan, Return Bend Reheater

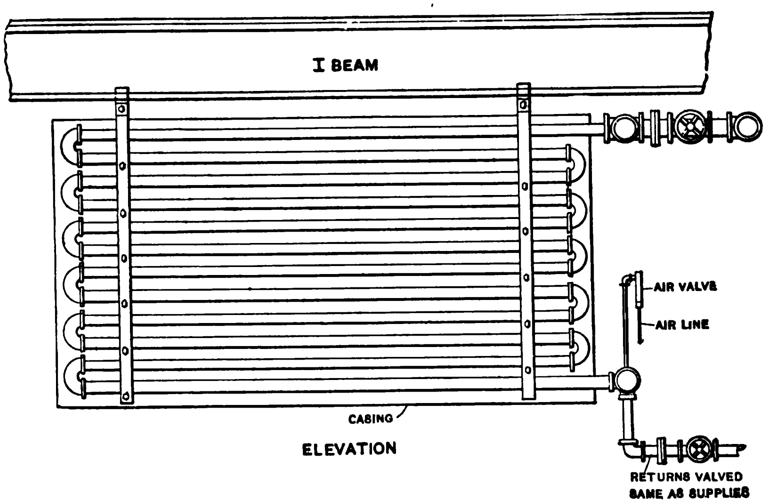


FIG. 99. — Elevation, Return Bend, Reheater

For maintaining an artificial water line in steam heating systems in order to seal the return risers and drips a tank with float as shown in Fig. 100 is sometimes used, operating a balanced valve in the return main. There is an advantage in this arrangement for large plants over traps in that a large size balanced valve may be operated in the main return, whereas more than one trap through which the water must pass would be required. Furthermore the artificial water line is apt to be maintained with less fluctuation with the water line controller as shown in Fig. 100 than by traps fitted with an equalizing pipe.

THE LOCATION OF CHECKS VALVES (FIGS. 101, 102)

The fact is often overlooked that the area of a check valve-seat is greater on the discharge than on the inlet side. This difference in area must be counteracted by a column of water rising on the inlet side until the water pressure overcomes the steam pressure exerted over the excess area on the discharge side. One frequently sees check valves in high pressure drip lines located close up to the mains. With this arrangement the checks almost invariably rattle. Some checks are much worse than others as to difference in area between discharge and supply sides; those with rounded seals presenting the least difference in area.

Checks placed directly at the discharge end of radiators or coils are pretty sure to hold water back in them, the water backing up till the excess of pressure on the discharge side of the check is overcome, the water being discharged periodically.

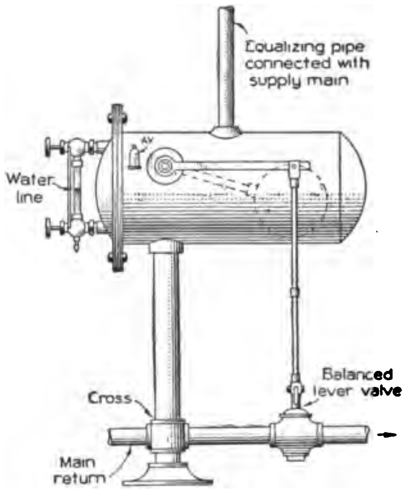


FIG. 100. — Artificial Water Line Controller

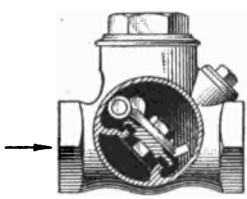


FIG. 101. — Swinging Check Valve

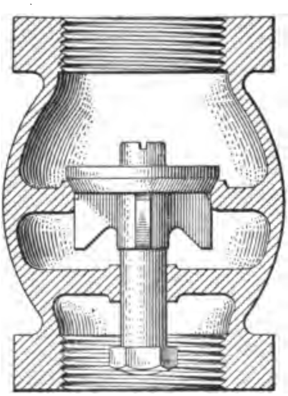


FIG. 102. — Angle Check Valve with Vertical Lift Disc

CHAPTER III

BOILER ENGINE AND PUMP-ROOM CONNECTIONS, CASTINGS, ETC.

Figs. 103 and 104 show one method of making connections at the front of a horizontal tubular boiler. When two or more boilers are set in a battery the feed pipe A B is extended across the boiler fronts and an angle valve is used in place of the elbow at C, the check valve and union being located between the two stop valves in feed line same as in Fig. 106*a*, so that stop valves can be closed each side of the check valve in case the latter has to be overhauled. The feed pipe enters the front head of the boiler just above the upper row of tubes and extends back inside the boiler to within about 2 feet of the rear head, where it branches in a tee toward the shell, perforations being provided in the pipe to permit the escape of the feed water.

Feed pipes should preferably be iron size brass, although in certain sections of the country, where the water is of such a nature that it does not attack iron, extra heavy wrought-iron pipes are used.

When brass pipes are installed it is customary to connect them with an extra heavy wrought iron nipple extending through the front head in order that no galvanic action shall take place between the brass pipe and the steel boiler head.

It is customary in some sections to use crosses with brass plugs in the feed pipes to provide for inspection and cleaning. As to sizes, it is not uncommon to find 1 in. feed pipes on boilers up to 36 in. in diameter, $1\frac{1}{4}$ in. pipes on 42 to 60 in. boilers, and $1\frac{1}{2}$ in. on larger ones.

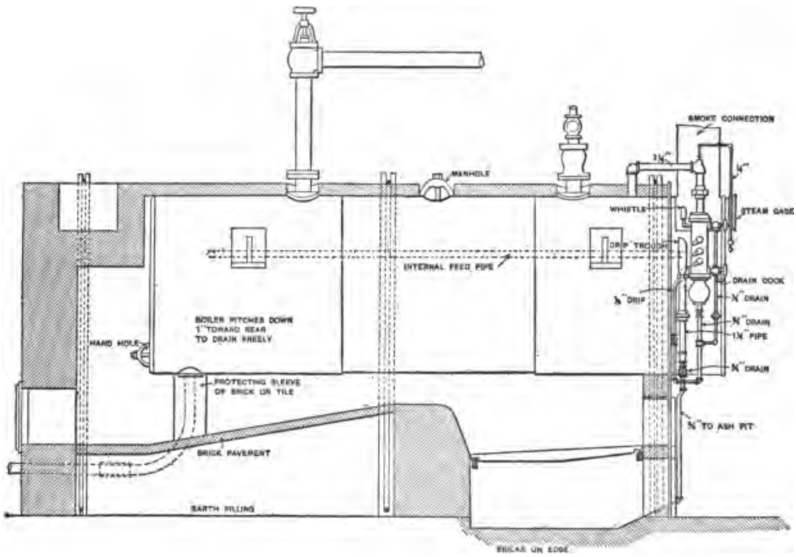


FIG. 104.—Section, Horizontal Tubular Boiler and Connections

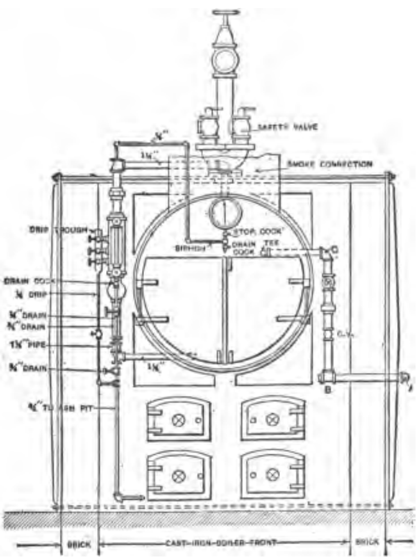


FIG. 103.—Horizontal Tubular Boiler, Front Connections

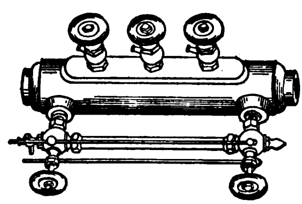


FIG. 105.—Water Columb

Figs. 106*a* and 106*b* show boiler front connections with a pair of 72 in. flush front boilers.

Crosses with brass plugs are used in the feed pipes and in the lower connections with the water columns. These have quick closing gauge cocks operated by chains and lever pattern try cocks.

The check valves have a valve each side of them to provide for overhauling.

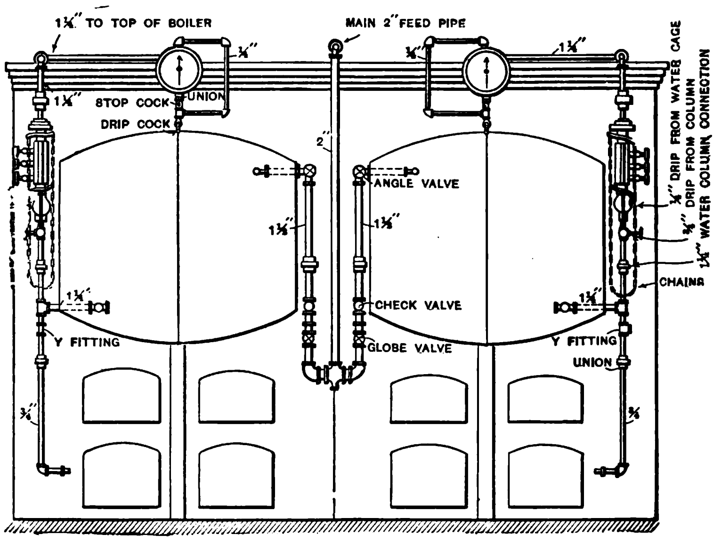


FIG. 106*a*. — Pair of Horizontal Tubular Boilers with Trimmings

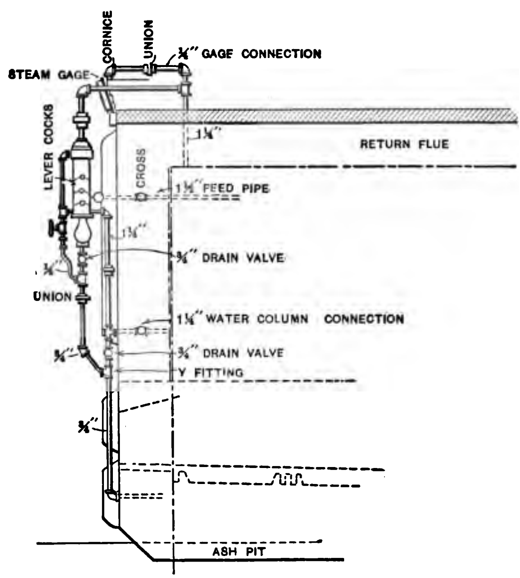


FIG. 106*b*. — Side View Boiler Front Trimmings

Fig. 107 shows a longitudinal drum water tube boiler with simple boiler feed and water column connections.

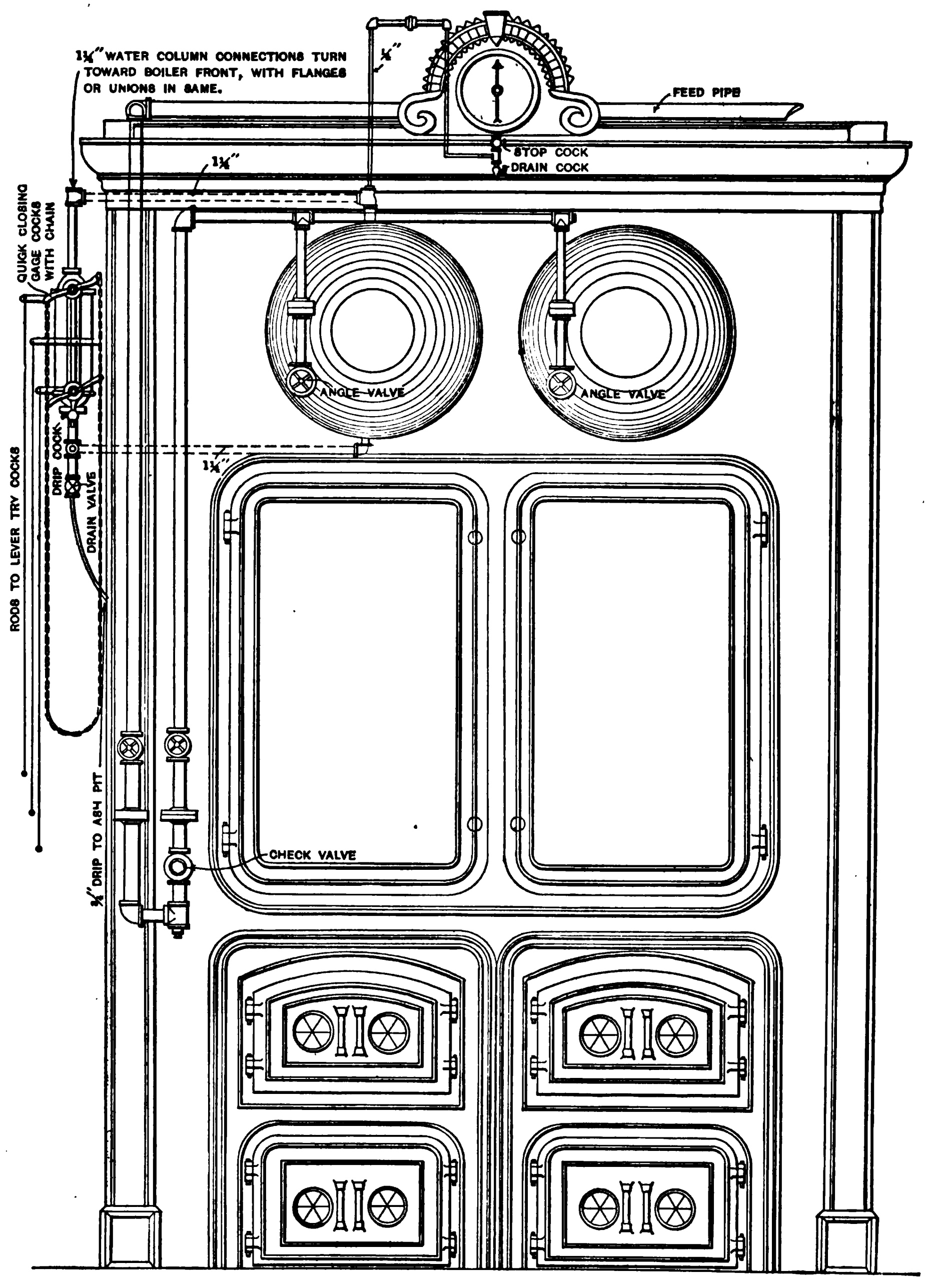


FIG. 107. — Water Tube Boiler Front Showing Fittings

Figs. 108*a* and 108*b* show front and side elevations of typical boiler feed and water column connections of a 300-hp Babcock & Wilcox type water tube boiler. The branch feed line from the main boiler feed header terminates in a combined stop and check valve at the front head of each drum.

The water column is connected by $1\frac{1}{4}$ in. connections, with flanges or with a flange union for the top connection and a right and left coupling for the bottom one.

The small pipe connections with water gauge, water column, and steam gauge are made up with right and left couplings or with ground brass unions.

Practice varies in different sections, owing to the character of the water, as to the use of iron size brass or extra heavy wrought iron pipe for the principal connections, the former being most commonly used in New England.

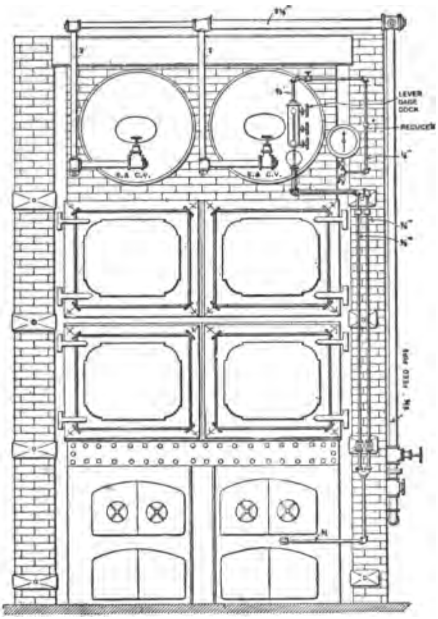


Fig. 108*a*. — Water Tube Boiler Front with Fittings

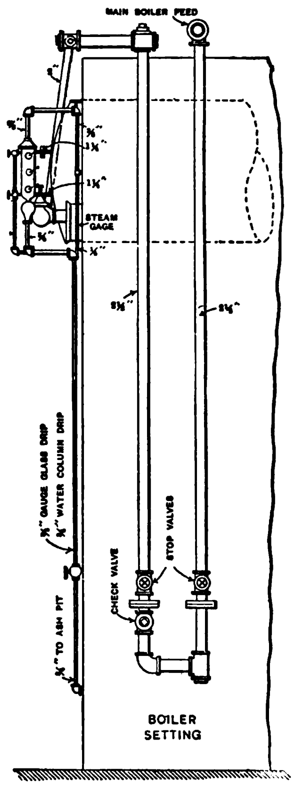


Fig. 108*b*. — Water Tube Boiler Fittings Side View

The water tube boiler shown in Figs. 107, 108*a*, and 108*b*, termed longitudinal drum type take up more height than can be secured for a given horse-power in some basements.

In such cases recourse is had to the cross drum type shown in Fig. 109, the drum running crosswise of the boiler at the rear where space is available.

Water column connections should be made directly with the drum as the distance is too great to bring the connections forward to the boiler front from fear that the pipes might become clogged.

The blow-off connections are made as usual with the mud drum at the rear.

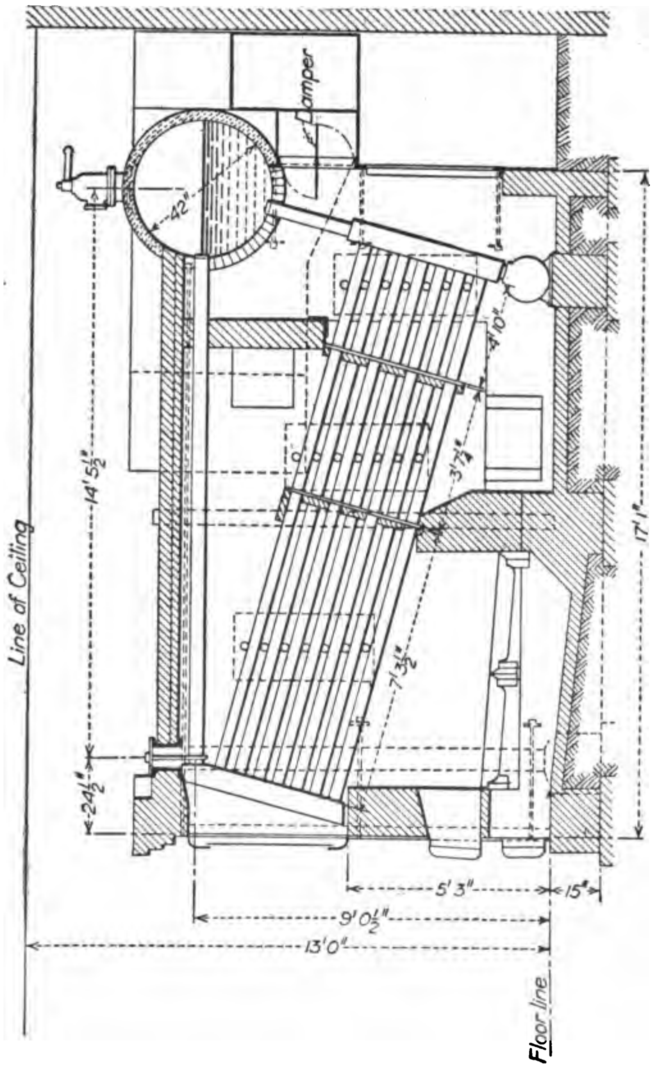


FIG. 109.—Cross Drum Water Tube Boiler

Fig. 110 shows a type of boiler, the "Stirling," in which capacity may be secured in the height where that dimension is ample and floor space may be lacking.

The steam supply is taken from the middle drum, water column connections being made with front one and feed water connection with the drum at the rear.

The blow-off connection is also shown. The front and middle drums are joined both above and below the water line by curved tubes just below the brick work as shown.

The middle and rear drums are connected in a similar manner above the water line.

The course of the gases is shown by the arrows, the smoke connection being made on top near the rear or in the rear wall as may be most convenient.

A number of illustrations are presented of commonly used boiler connections. Many others could be shown, but it is unnecessary to present these, provided the fitter bears in mind that water pockets should be avoided and that expansion must be provided for. In case the conditions are such that the piping must be arranged so that water may collect at certain points, these points must be properly dripped. In addition to expansion strains, others may be brought about by a settling of the boilers, a sagging of trusses or beams from which the pipes are suspended or from other causes. With ample length in the various connections the spring of the pipes will go far to relieve the strain on the fittings.

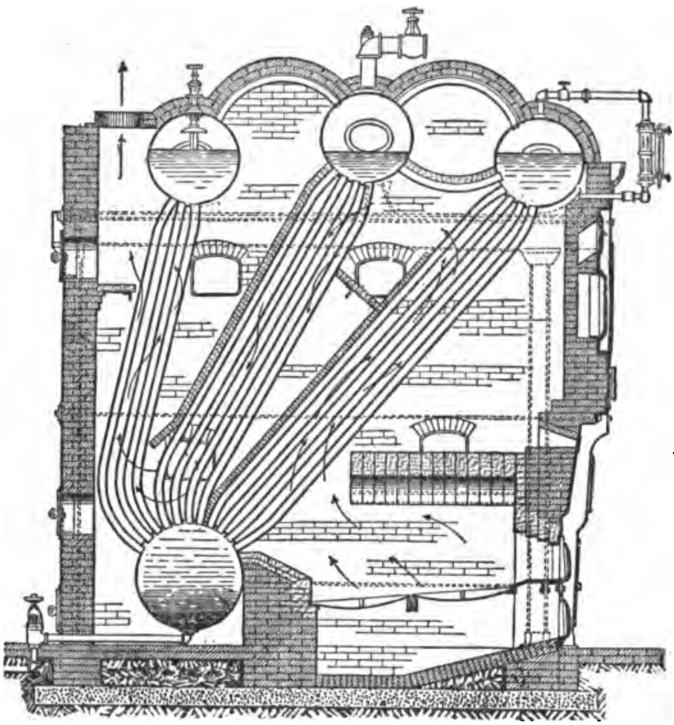
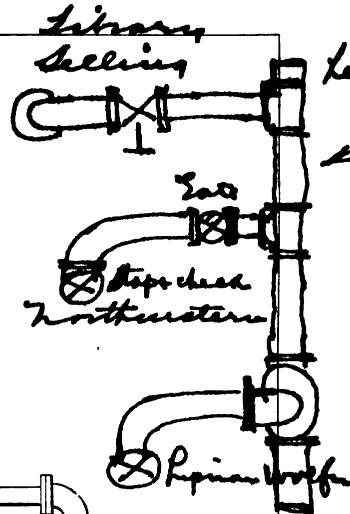


FIG. 110.—Sectional View of Stirling Boiler—side Elevation

One of the most common methods of making the main steam connection with a boiler is shown by Fig. 111, a flanged angle valve being placed as indicated to shut against the steam pressure in the boiler so that the valve may be repacked without taking the pressure off the boiler. When there is a battery of boilers the writer favors placing the valve where indicated in Fig. 112, arranged to shut against the steam in the header. This valve may be packed with full steam pressure in the header, the boiler controlled by this valve to be shut down at such times.

For a first class job the arrangement shown in Fig. 113 is recommended, each boiler in the battery being double valved. With a pair of valves between the boiler and the header it is pretty safe to put water pressure on one of the boilers for testing while steam pressure is on the header.



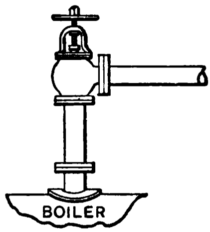


Fig. 111

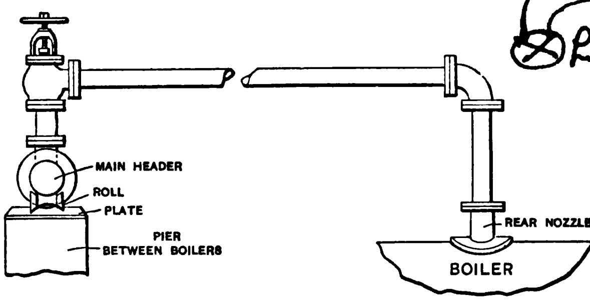


Fig. 112

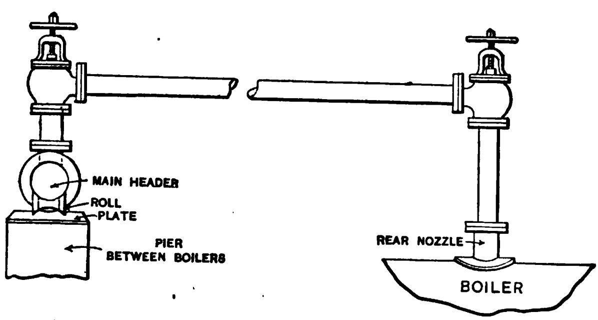


Fig. 113

Several Methods of Making Steam Connections with Boilers

Fig. 114 shows a neat arrangement of boiler connection, a bend being connected with the boiler nozzle and leading to an angle valve placed above the main header. If the header is of considerable length the nipple should be inserted as shown between the angle valve and the tee in the header to provide a swivel when the header expands or contracts.

Fig. 115 makes a very neat form of connection made up of two bends with a gate or globe valve at the highest point.

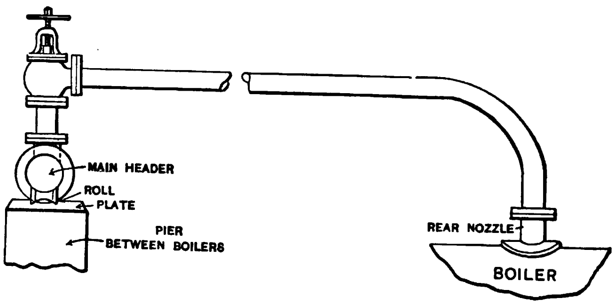


FIG. 114

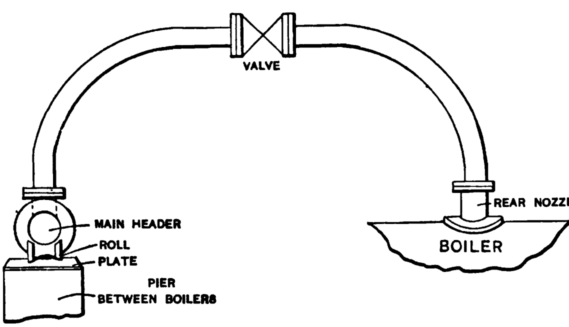


FIG. 115
Several Methods of Making Steam Connections with Boilers

Fig. 116 represents a method of connecting boilers with a pair of headers in a manner that is recommended by certain fire insurance companies, the object being to provide for having steam on the fire pump and boiler feed pumps at all times, these pieces of apparatus being cross connected with the main and supplementary headers. A stop valve should be placed in the steam main between the boilers and engines to be closed in case the fire should approach the engine room, so that the operation of the pumps would not be interrupted as long as the boiler house should stand.

It is of interest to note the difference in the method of setting boilers illustrated by Fig. 104 and Fig. 116. In the former the smoke connection is shown at the front leading to a steel plate breeching extending across the battery of boilers.

When boilers are set as shown in Fig. 116 the gases return over the top to a brick smoke duct at the rear, each boiler being separately controlled by a damper, the draft on the battery being regulated by a main damper. Another feature illustrated in Fig. 116 that is worthy of note is the turning up of the discharge from the safety valves to avoid danger to a person on top of the boilers in case a pop valve should suddenly open.

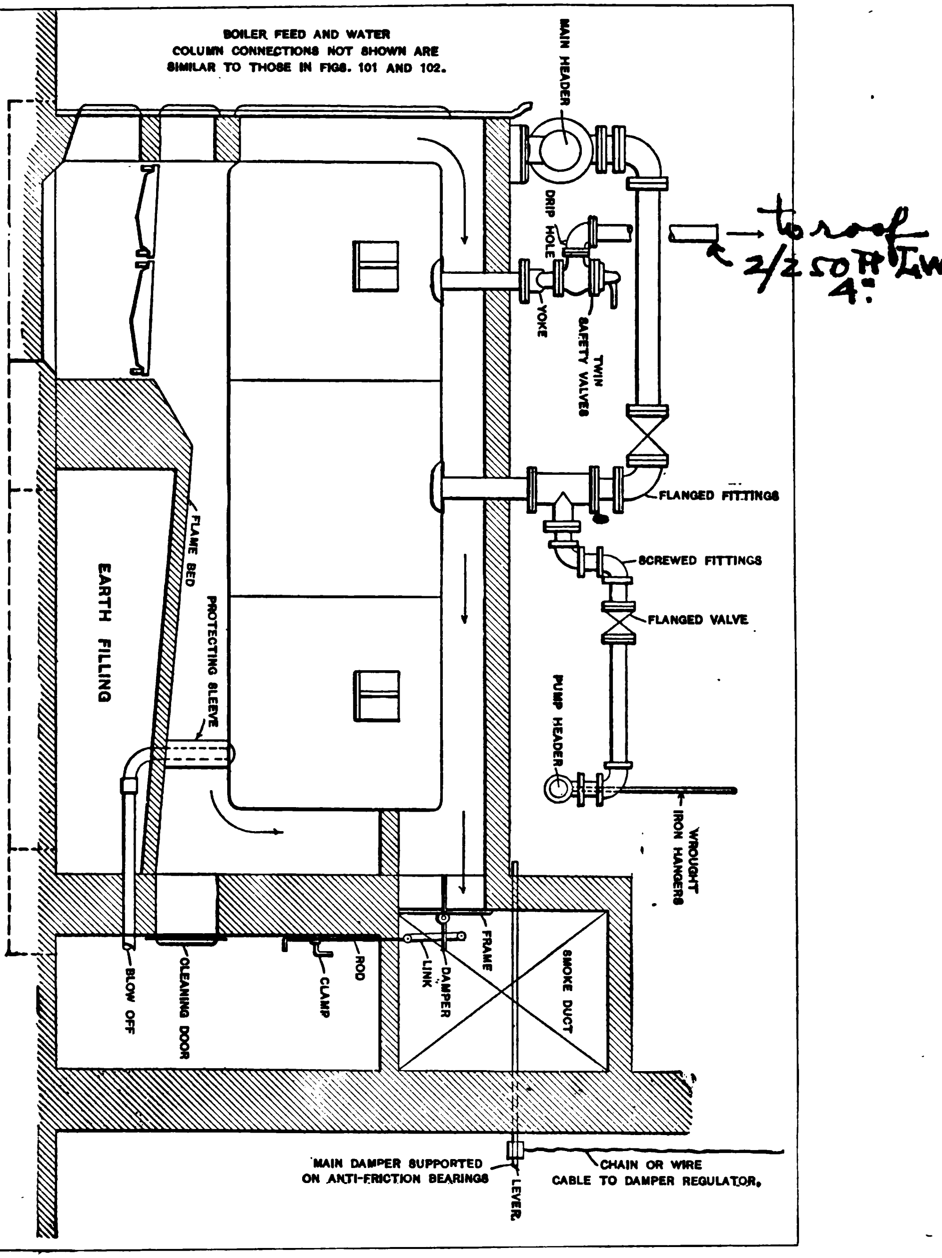


Fig. 116. — Section, Horizontal Tubular Boiler and Steam Connections

In large plants the boilers and engines are often piped on the loop or ring system, a stop valve with by-pass being placed between each two boilers or engines as shown in Fig. 117. In case a gasket has to be inserted in the main header between valves *a* and *b*, for example, these valves are closed and boiler B is temporarily laid off, steam from A and C supplying the loop or ring. Previous to the common adoption of this method of piping, two sets of mains were run in plants where a shut-down would be a serious matter and had to be guarded against.

The main header in the several illustrations is shown resting on rolls and plates, the latter being supported by brick piers built on the walls of the boiler setting. If the header is level it should be dripped at both ends through traps, these as a rule discharging to a tank or to an open feed water heater, if there is one, the water of condensation to be pumped back to the boilers. In case the header has a good pitch the drip is of course connected with the low end only. In large plants traps are eliminated by the use of the steam loop or Holly system for returning high pressure drips to the boilers.

The blow off connections with high pressure boilers are commonly made with 2 in. extra heavy wrought pipe; $2\frac{1}{2}$ in. connections are often used for boilers of 150 hp. and larger. Fittings should be avoided as far as possible, bends being used instead. Where the pipe is subjected to the action of flame it should be protected by brickwork built in front of it in the form of a V. Fittings should be of extra heavy pattern, good for 250 lb. working pressure. It is customary to make blow off connections extra heavy throughout, although, of course, no great pressure can occur between the blow off cock or valve and a properly vented tank. Extra heavy flanged unions should be placed at intervals to provide for readily disconnecting the blow off pipes in case of repairs. If flanged fittings are used comparatively few flange unions are necessary.

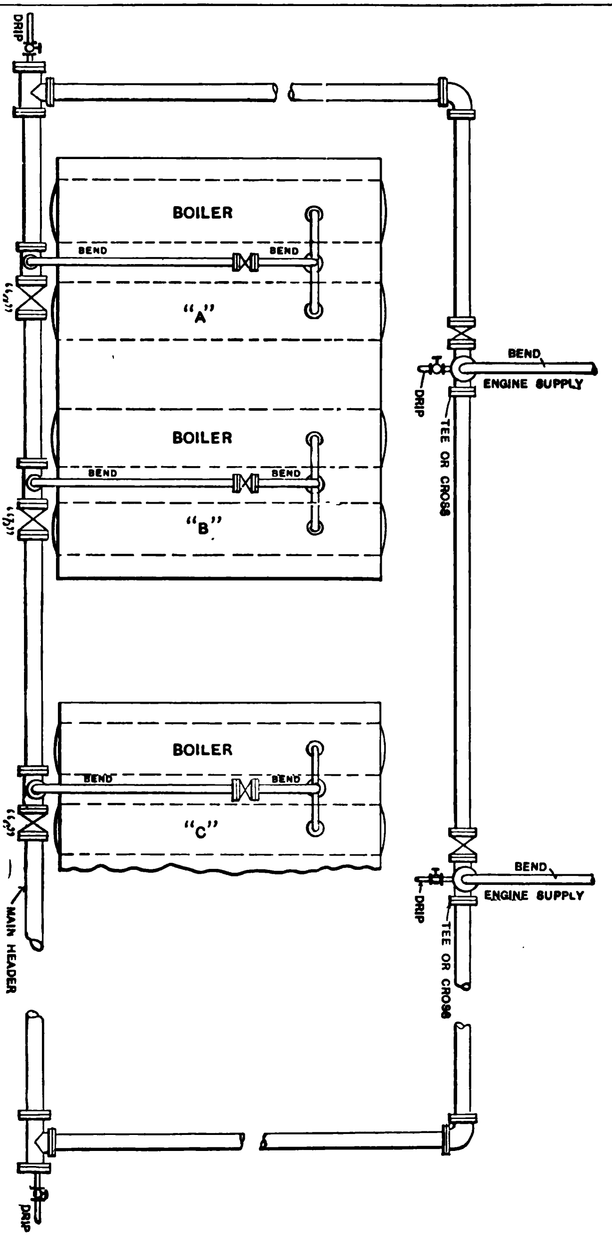


Fig. 117. — Plan, Loop, or Ring System of Connecting Boilers

Asbestos packed cocks similar to the one shown in Fig. 118 have been and perhaps are still used more than other devices for controlling the discharge through blow off pipes, although blow off valves of different types have been very generally adopted for high pressure service during the past few years. Several types of these valves are illustrated by Figs. 119, 120, 121, and 122.

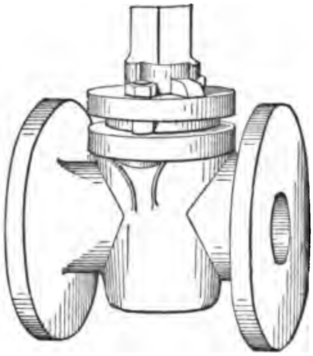


FIG. 118

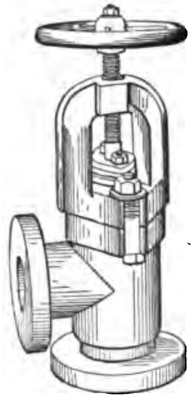


FIG. 119

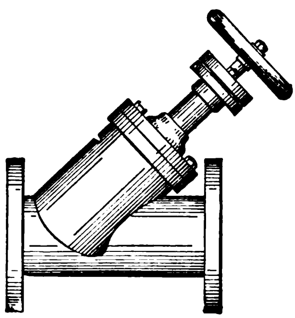


FIG. 120

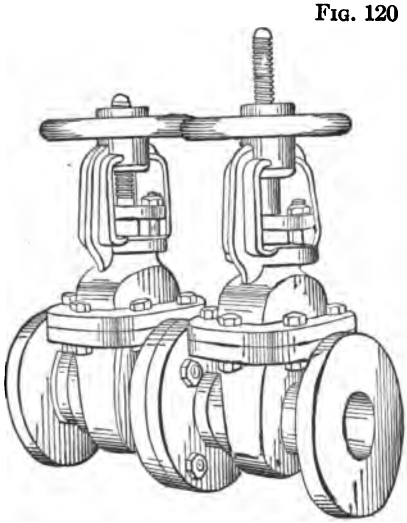


FIG. 121

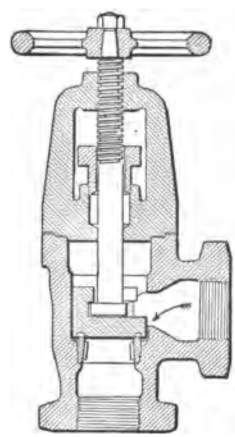


FIG. 122

It is well to use a valve and a cock or a pair of valves on each boiler. The former are often arranged as shown in Fig. 123. The writer, however, prefers placing the cock outside the valve. The reason for this arrangement is that the valve is easier to repair and can be made to take the wear. In blowing down the cock is first opened, then the valve, these to be closed in the reverse order, thus keeping the pressure off the cock when it is operated. When a single cock is used on each boiler it is well to guard against leakage by placing a heavy gate valve in the blow off pipe between the blow off tank and the branch to the boiler nearest the tank.

It is desirable to provide a plugged tee or other means for determining whether or not there is leakage past the cocks and valves. One of the manufacturers of the blow off valves used in pairs, as shown in Fig. 121, states that since the scale-forming impurities passing through these valves quickly destroy the seats, causing them to leak, and since it is impossible to avoid this wear, they recommend a type of valve in which the seat can be easily renewed, thus keeping the valve tight at all times. These valves are angle pattern, with flanged ends, and it is recommended that they be connected as shown in Fig. 124. The operation is as follows:

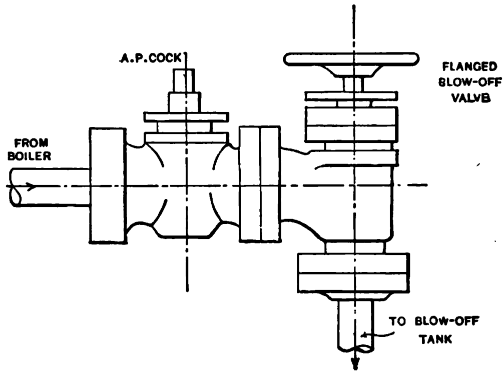


FIG. 123

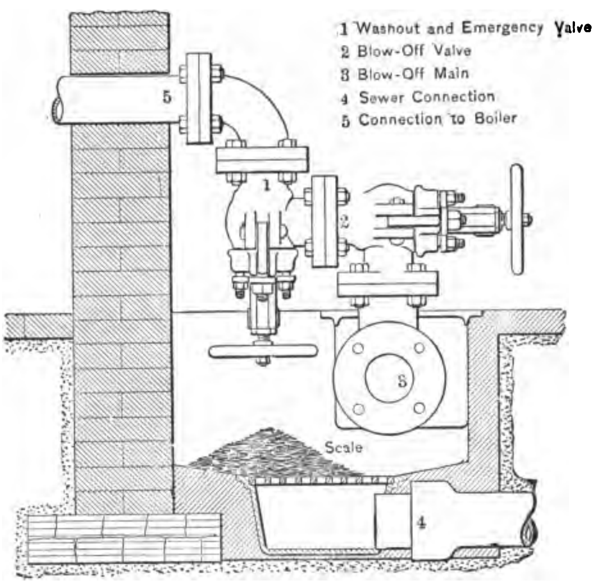


FIG. 124

"When boiler is in use valve No. 1 is entirely open and not used for blowing off. No. 2 is the regular operating valve for blowing off. In case of leak in No. 2 valve then No. 1 can be closed and No. 2 repaired. When boiler is being cleaned valve No. 2 is kept closed to avoid scalding the boiler cleaner, as would occur if he ran waste wash water into the blow off pipe when another fireman might be blowing off some other boiler. With these two valves he shuts off blow off main entirely with valve No. 2, removes bonnet from valve No. 1, and drains his boiler wash water and scale into sink made in floor, same having catch basin connected with sewer. By doing this he is safe against back water from blow off main, it keeps all loose scale out of blow off pipe and reduces the resistance of water leaving boiler and enables him to wash boiler out more quickly. Where single boilers are used and are not in continuous operation, allowing ample time for repairs, a single valve could be used. In large power plants where a number of boilers are in continuous use and connected into one blow off main, the use of two valves would give the best results."

In some cities it is the practice just to "cover the law" by providing a plain blow off tank similar to the one shown in Fig. 125. The theory of the operation of these tanks evidently is that the water under boiler pressure flows in a great deal faster than it can pass out to the sewer, since the tank is freely vented and the pressure on the water is relieved. A much better type of tank is that shown in Fig. 126, where the discharge pipe is water sealed inside the tank, thus preventing the blowing of steam to the sewer.

If located in a cold place the drain must be left open after blowing down. It is extremely important that the vent pipe from the tank be so located and graded that there will be no pockets in which water from condensed vapors can lodge and freeze. In cities an exhaust head should be placed at the top of the vent pipe for the purpose of condensing the vapors.

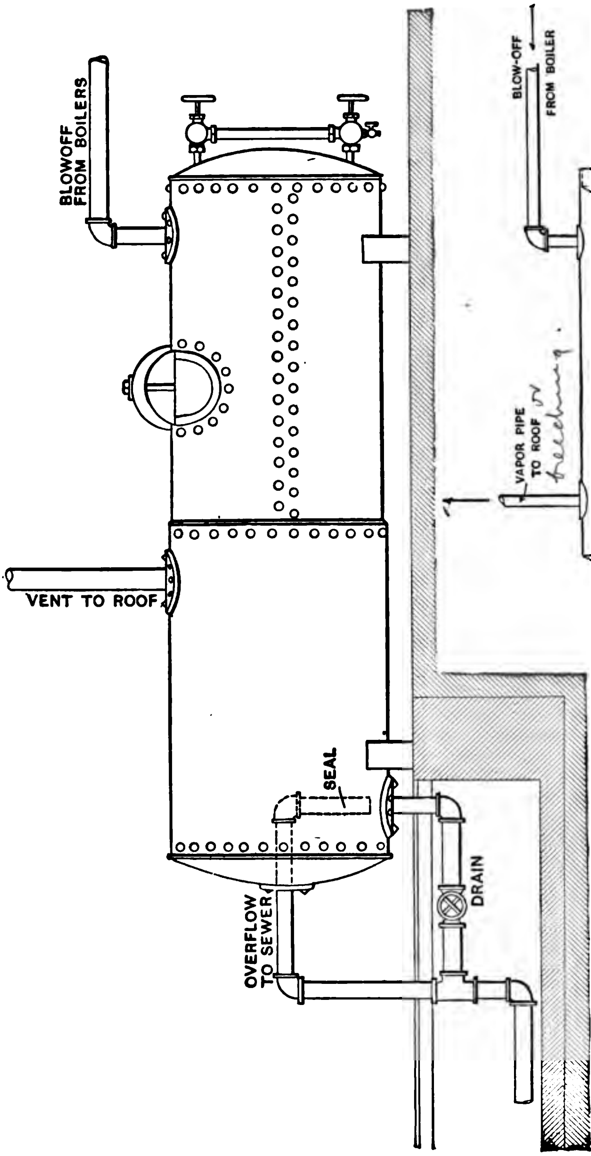


FIG. 126.—Blow off Tank Connections

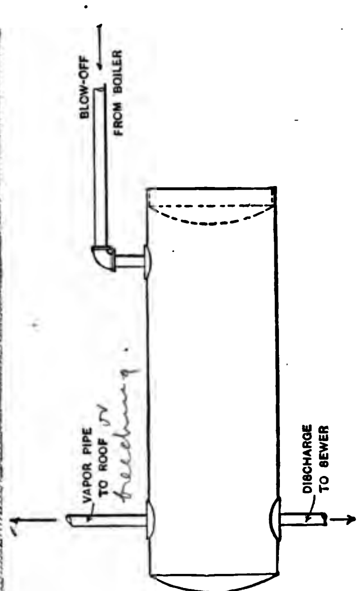


FIG. 125.—Small Blow off Tank

Fig. 127 is copied from the October, 1906, number of the *Locomotive*, published by the Hartford Steam Boiler Inspection & Insurance Company, from which we quote as follows:

"It is injurious to a sewer to blow the contents of a boiler into it directly, and many cities have ordinances requiring that an intermediate receptacle of some sort shall be provided, in order that the sewer may be protected from the destructive action of the direct discharge. It is objectionable, also, to fill the sewer with hot steam, and when tanks are provided they should be so constructed that they will permit the steam and water to separate, the steam being allowed to escape into the air through a vent pipe at some point where it will not constitute a nuisance, while the water is either permitted to flow from the tank into the sewer under the combined influence of gravity, and such pressure as may exist within the tank, or pumped out of the tank when the conditions are such that the assistance of a pump is required.

"When blow off tanks are employed, it is exceedingly important that they should be made strong enough to withstand a considerable pressure. Too often they are regarded in the light of mere vessels which are to receive the contents of the boiler without being themselves subjected to any serious pressure. This is, indeed, the ideal function of a blow off tank; and yet in designing such a tank we should always bear in mind the possibility of its being subjected to a pressure of some magnitude, through the occurrence of conditions that were perhaps not foreseen when the plant was installed. The neglect of this precaution has resulted in many serious accidents, often accompanied by loss of life.

"A correct form of construction for a blow off tank is shown in Fig. 127. This tank is built of steel, the sides being $\frac{3}{8}$-in. thick, and the heads $\frac{1}{2}$-in. The shell is double riveted, and the heads are bumped to a radius equal to the diameter of the shell. The blow off pipe enters at the side, near the upper head, the opening for it being reinforced by riveting to the shell a piece of plate $\frac{1}{2}$-in. or more in thickness. The water that is discharged into the tank passes out again through a siphon, which comes down to within 6 inches or so of the bottom of the tank, and is designated in Fig. 127 as the

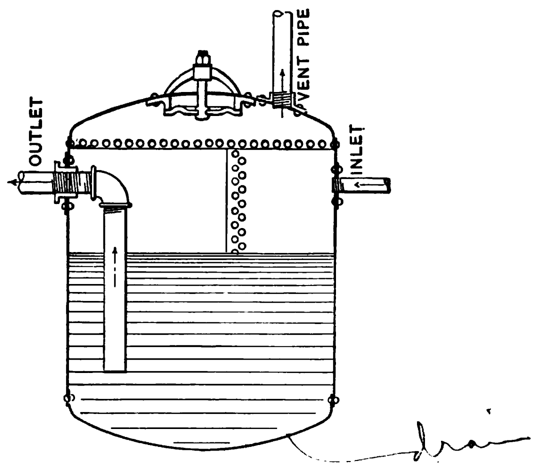


FIG. 127. — Blow off Tank Connections

'outlet.' The siphon is made of pipe 3 or 4 in. in diameter (the diameter of the blow off being assumed to be 2 in.) in order that the water may have the freest means of escape. The elbow in the siphon is secured to a short nipple, which enters a bushing that is screwed into a reinforced opening in the shell. Another piece of pipe, of diameter equal to that of the internal part of the siphon, enters the bushing on the outside, and leads to the sewer. A vent pipe, preferably 4 in. in diameter, at least, enters the upper head through a pressed steel flange, the collar of which is of sufficient length to afford a proper holding power to the threads on the end of the pipe. Finally, a manhole is provided, so that the interior of the tank may be readily accessible for inspection and repairs, and for the removal of such deposits as may accumulate in it."

Continuing the quotation from the *Locomotive* of October, 1906, the Hartford Steam Boiler Inspection & Insurance Company has the following to say regarding boiler blow off connections:

"We do not insist upon blow off tanks having the particular design shown in Fig. 127 (June 29, page 59), but we do insist upon their having a strength amply sufficient to enable them to resist any pressure to which they may be exposed. The size and shape of the tank, and the sizes of its outlet and vent pipes will naturally vary from one steam plant to another, the number of boilers in the battery, and the capacity of each, having a considerable influence upon these elements. Blow off tanks are often placed underground, but we greatly prefer to have the tanks and their pipes so situated that they can be easily examined at all times.

"As regards the intensity of the pressure that may exist in a blow off tank, we can hardly say more than that it depends upon the sizes and lengths of the pipes, upon the size of the tank, upon the number and capacity of the boilers that may be blown off at the same time, upon the working pressure that is carried in the boilers, and upon various other circumstances. In a tank that is well designed, and adapted to the work that it has to do, the usual pressure, while blowing off, may be from 10 to 20 lb. per square inch, though it should be understood that this estimate is given

merely for the information of those who have had no experience with such tanks, and that it does not pretend to represent the facts of general practice except in the very roughest way.

"A boiler should never be blown off into a tank that is already full of water, or nearly so; for it is easy to understand that the violent discharge of more water into such a tank is certain to produce a very considerable pressure, especially in the first few moments, before the flow out through the exit pipe has become fully established. It is hard to say how great a pressure might thus be produced, but if the blow off were suddenly thrown wide open, so that the discharge due to the full diameter of the pipe could be turned instantly into a tank solid full of motionless water, it is probable that the initial pressure that would be realized in the tank would be comparable with the pressure in the boiler, and it might conceivably be even greater. This fact, taken in connection with the known fact that a sudden load or pressure has twice the disruptive effect of an equal load when applied gradually, shows how serious the consequences may be, of blowing off into a tank already full of water.

"If the outlet of the tank should become partially or completely stopped up from any cause the water from the boiler will accumulate in the tank, since its only means of escape would then be through the vent pipe, which, under normal circumstances, conveys nothing but steam. In many cases the vent pipe passes up to the top of a high building, and if the water in the tank should accumulate until it overflows through the vent pipe it is plain that the tank may be exposed to a considerable pressure. For example, if the vent pipe were 100 ft. high, and were full, the water within it would produce a static pressure upon the tank of something like 42 or 43 lb. per square inch; and this pressure would be realized, no matter how gentle the flow from the blow off, the action here described being distinct from that contemplated in the last paragraph, where the pressure was due to the violence of the discharge into a full tank, without reference to the static head to which the tank might be exposed.

"The vent pipe itself is also liable to become more or less

completely closed in winter in our Northern latitudes, through the action of frost, particularly if the blow off pipe leaks slightly. Small quantities of vapor, passing up through the vent pipe in cold weather, may give rise to a coating of ice about the free end of the pipe, and this may increase until the pipe is seriously reduced in area, or possibly stopped up entirely. . . .

"Whatever the causes of pressure in blow off tanks may be, it is certain that such tanks explode from time to time, owing to the existence within them of pressure not contemplated by their designers. Our main contention is that blow off tanks should be made strong enough to safely withstand any pressure to which they may be subjected, through the failure of either the plant or the workmen to operate correctly."

As to the size of blow off tanks the custom varies widely in different cities; in some they are made of sufficient capacity to hold all the water from one of the boilers when emptied. The water is then allowed to cool off before being discharged to the sewer. Another advantage claimed for thus liberally proportioning the blow off tank is that when the steam plant includes but one boiler and the tank is below the level of the sewer, with no means of pumping out but a steam pump, the entire contents of the boiler may be discharged to the tank and allowed to remain there until the boiler is again fired, when steam may be had for the blow off pump. A cold water jet is frequently applied to blow off tanks too small in size to give time for the water to cool. It is customary with some engineers to have brass cooling coils placed in the blow off tank; through these cold water is required to pass.

It is better to secure blow off tank capacity in length rather than in diameter, since an increase in diameter involves an increase in the thickness of the metal to maintain a given strength. It should be borne in mind that with a given pressure the longitudinal seams of a tank are subjected to twice as great a strain as the transverse or ring seams.

1/24 vol of boiler regulating tube
(provide for as many boilers as are to be blown at one time)

When horizontal tubular boilers are used for heating with a gravity return system the main return and blow off are often arranged somewhat as indicated in Fig. 128. A separate

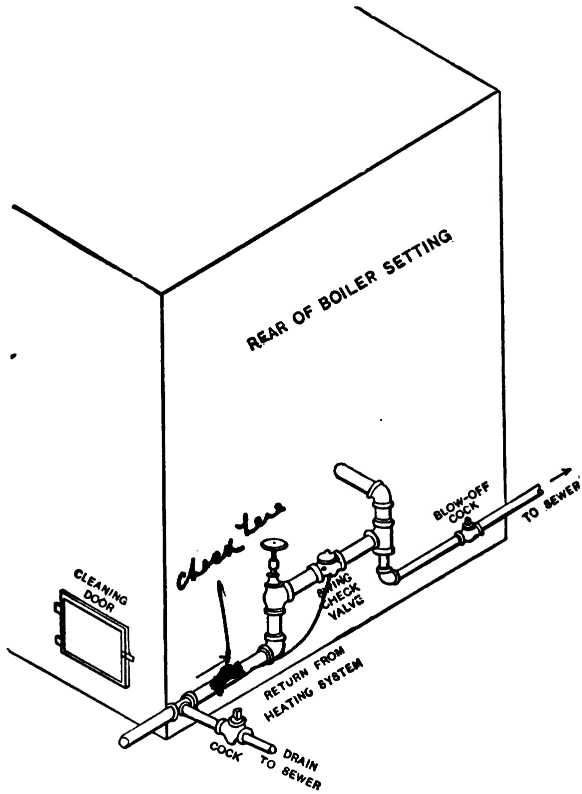


Fig. 128. — Return and Blow off Connection with Boiler

valved branch is provided for draining the system without necessitating the emptying of the boiler. It is preferable to place the check valve outside of the stop valve in main return to provide for overhauling same without emptying the boiler.

Fig. 129 shows piping connections of one of a group of engines. A steam separator is supposed to be located in the main line instead of placing one at each engine, as is the common practice when they are some distance from the boilers and the condensation would be considerable. The expansion of the main is provided for by the nipple at N, and the thread below the elbow at E, which will allow an angular movement of the horizontal branch when the main expands. It is well in connecting the cylinder lubricator to make the condensation pipe above it of ample length. The throttle drip is shown bent around the cylinder — a neat arrangement readily accomplished with the ½-in. brass pipe commonly used. This drip is shown independent of the cylinder drips. While this is preferable it is not absolutely necessary provided check valves are properly placed. The underground duct is shown with the cast iron plates removed from the greater part of it.

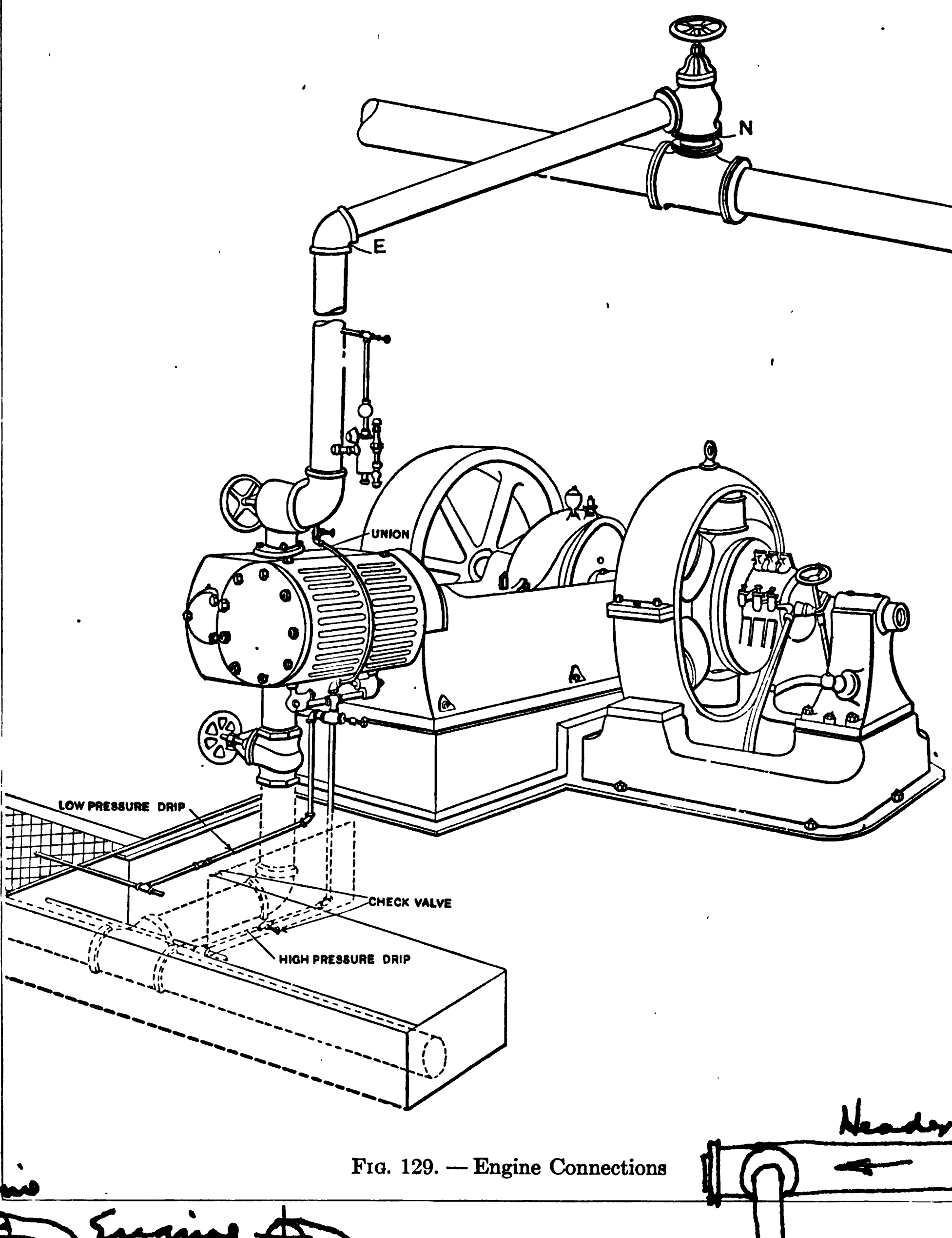
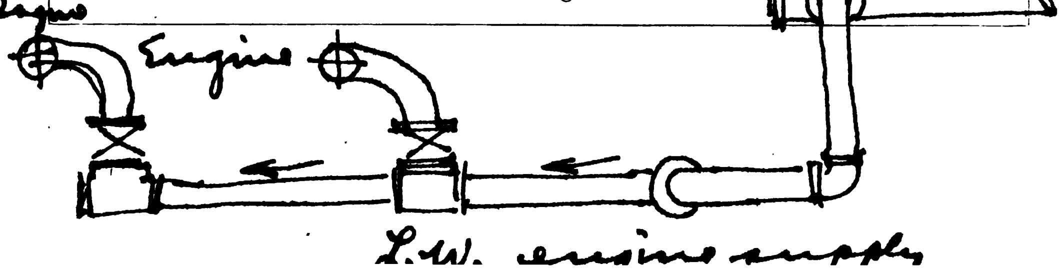


FIG. 129. — Engine Connections



Figs. 130*a* and 130*b* show by plan and elevation a pressure reducing valve with by-pass. The valve shown is of the low pressure pattern small on one side and large on the other. The weight may be adjusted to give the desired pressure on the low pressure side as indicated on the gauge which is an essential adjunct of this equipment.

The pipe connecting the gauge with the low pressure side should be 8 or 10 ft. in length, in order to enter the main pipe at a point where the pressure will represent the average of that in the line.

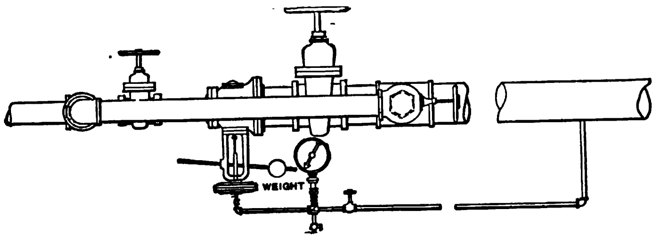


FIG. 130*b*

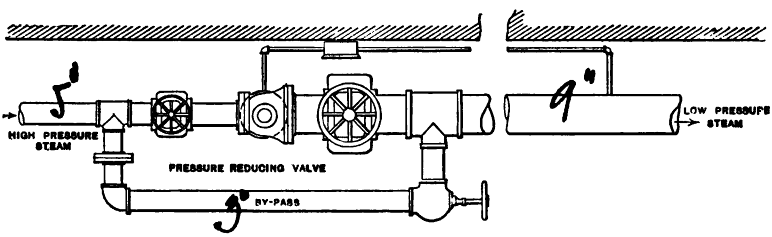


FIG. 130*a*

Plan and Elevation Pressure Reducing Valve with By-pass

Fig. 131 shows a closed feed water heater with oil separator, by-pass, etc. Often the oil separator may be placed in the main exhaust line near the engine, which location is equally as good as the one shown. This oil separator is trapped through a grease and oil trap to drain or sewer.

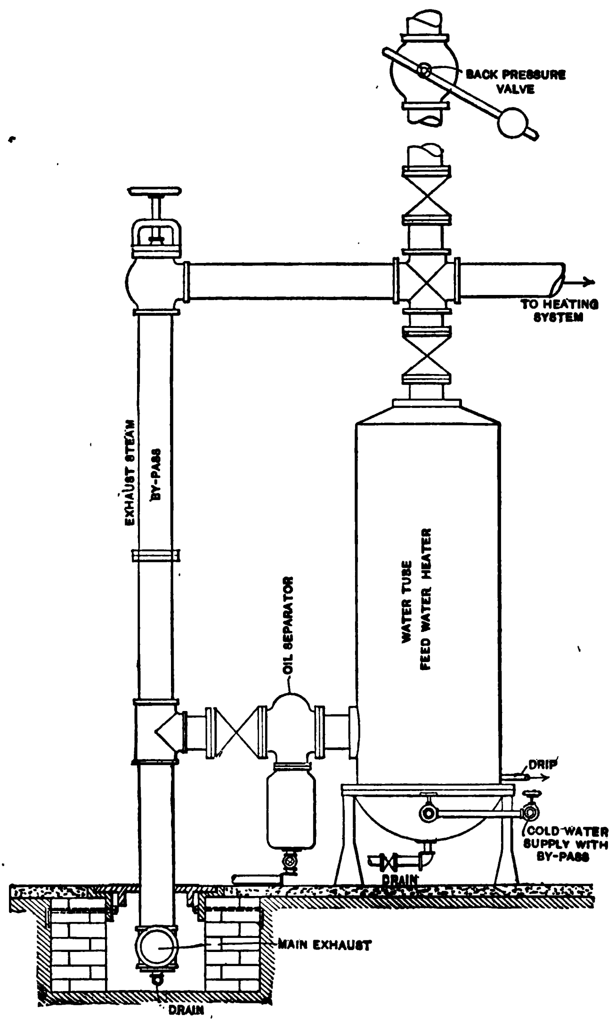


FIG. 131. — Closed Feed Water Heater and Connections

There is an element of danger in the arrangement, shown in Fig. 132 as in case valves A and B happen to be closed when C is opened and engine started an excessive pressure will be brought to bear on the interior of the heater, causing it to burst. To avoid this danger a weighted valve similar to a back pressure valve should be placed at A, which would open in case of excessive pressure.

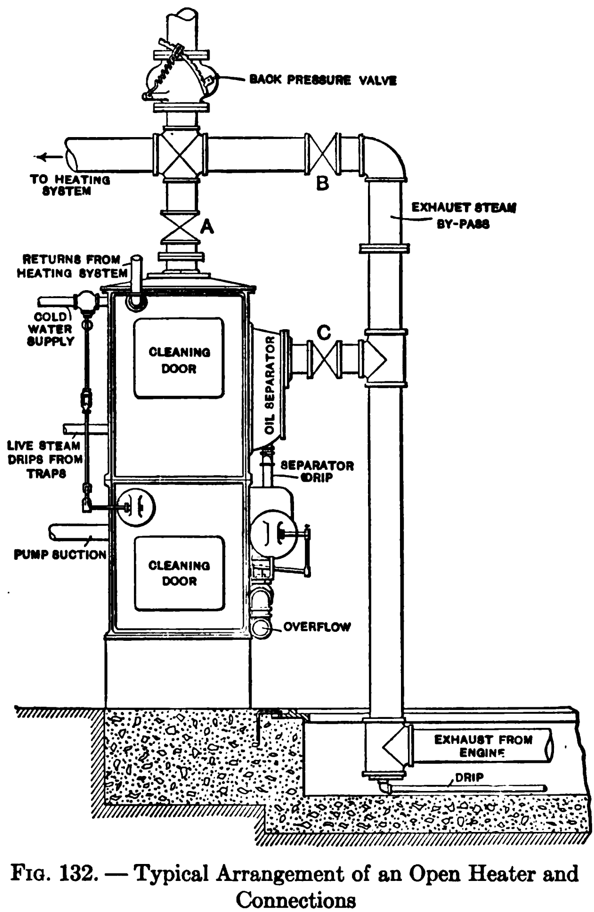


FIG. 132. — Typical Arrangement of an Open Heater and Connections

Fig. 133 shows a heater with preference connections.

The exhaust pipe is so arranged that the steam will shoot into the heater in preference to turning at right angles to enter the pipe leading to the exhaust head. Only one valve is necessary to shut off the heater, a considerable saving in material being made over the arrangement shown in Fig. 132.

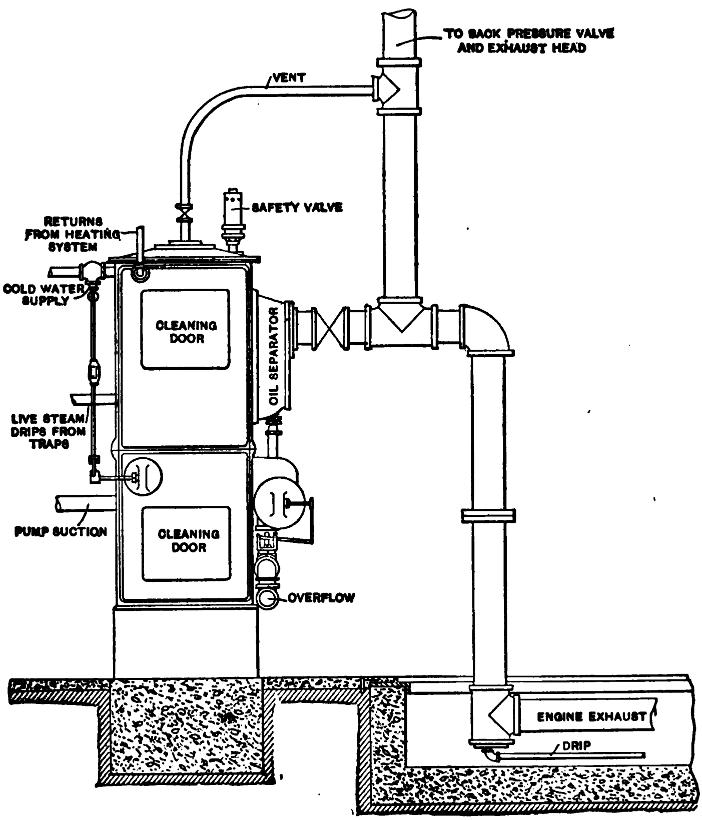


FIG. 133. — Heater with "Preference" Connections

In addition to Figs. 132 and 133 showing heater connections Fig. 134 is given showing what is termed a preference connection for open type heaters having a single exhaust steam connection. The outboard exhaust connection is taken from the outlet of tee, the heater being connected with the run of the tee.

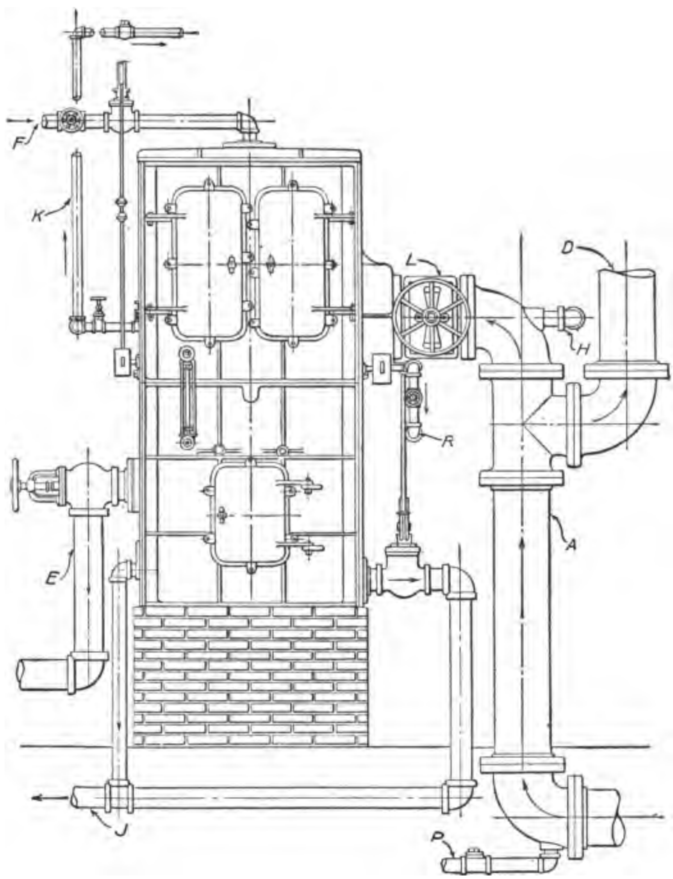


FIG. 134. — Heater with Preference Connections

Fig. 135 shows one method of supporting cast iron covering plates for ducts, the rails along the top of the duct being held in place by anchors, as illustrated. With concrete walls it is well to build up to within an inch or an inch and a half of the bottom of the rail, setting this in place with the top level with the floor line, grouting in the space under the rail.

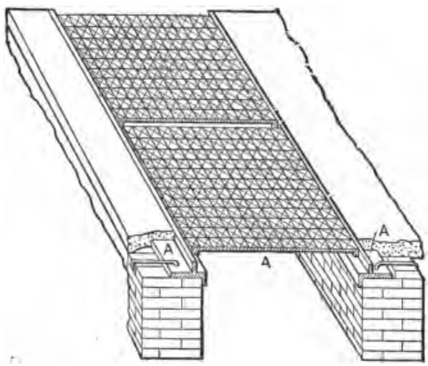


FIG. 135. — Cast Iron Trench Plates and Rails or Borders

Other types of rails or border bars are shown in Figs. 136 and 137. Ordinary steel tee bars are often used along the top of the duct walls, as indicated in Fig. 138. These are anchored by $\frac{3}{8}$-in. irons turned at right angles at each end, as shown. The bars are punched for these irons at intervals of about 3 ft.

A variety of styles of markings are shown, the diamond pattern being perhaps the most common, with the fluted plates a close second. The cast iron plates should be heavily ribbed underneath to insure strength. At intervals they should be provided with holes for inserting a hook to facilitate their removal.

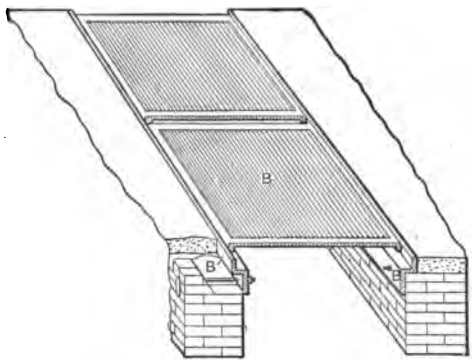


Fig. 136

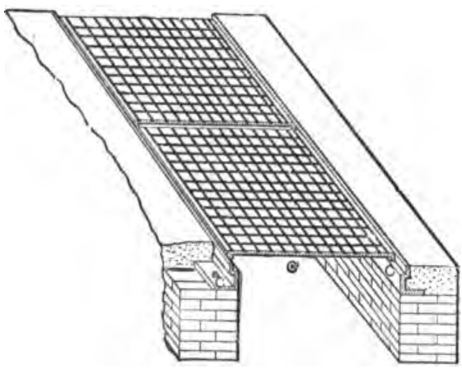


Fig. 137

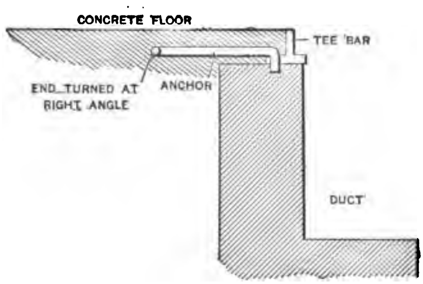


Fig. 138

Plates about 3 ft. square make a good flooring in front of boilers, when supported on tees and angles, as illustrated in Fig. 139. When using fluted pattern plates for this service they should be set with the groove perpendicular to the boiler front to facilitate shoveling. Pressed steel plates are now very commonly used for duct covers and for boiler room flooring. Care must be taken in their use, however, to avoid trouble from warping.

In the better class of plants it has become the custom to use cast iron combined bed plates and drip pans under the pumps. See Fig. 140.

These take the place of copper or zinc pans and make a satisfactory finish for the top of the foundation. Concrete foundations are, perhaps, more commonly used than brick. With the latter, if the corners are laid up with "bull nose" or "jamb" bricks and the radius of the pump pan corners is made to correspond, the effect is pleasing.

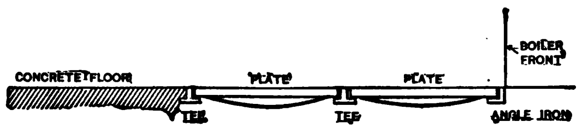


Fig. 139. — Cast Iron Floor Plates for Boiler Rooms

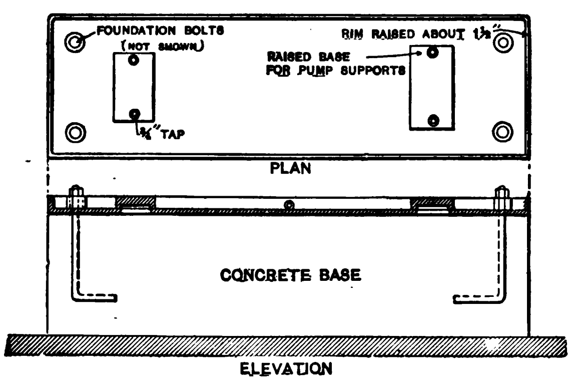


Fig. 140. — Cast Iron Bed Plates and Drip Pans Combined

In certain locations for pumps space is lacking to place them side by side or end to end and leave sufficient space around them. In such cases the double deck arrangement illustrated in Fig. 141 affords one solution of the difficulty. Substantial supports shouldered near the ends should be used to give the necessary rigidity, these to be located at the four corners.

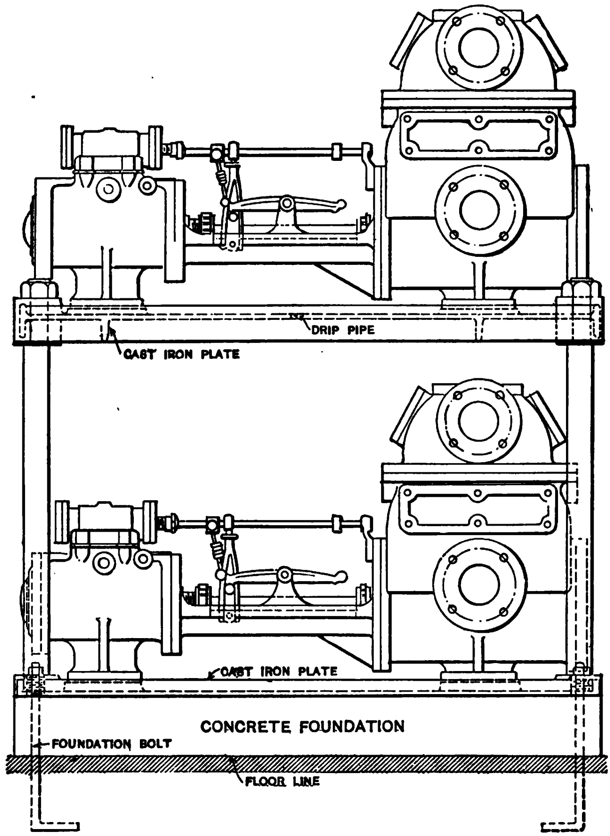


Fig. 141. — Double Deck Pump Supports with Bed Plates

Cast iron tanks, on account of their greater durability than steel plate, are used to a great extent for sump tanks in buildings. They are not intended to stand much pressure and should be freely vented to the atmosphere. No pit is necessary; they are merely buried. The construction of the tank illustrated in Fig. 142 is clearly shown and needs no description. The company that manufactures tanks like the one illustrated also makes cylindrical tanks for sinking in the ground without endangering foundation walls. The manufacturer states: "They are sunk in place caisson fashion by excavating from within, their weight carrying them down as fast as the earth is removed, the exterior being smooth. The sections are bolted together in rings, and these rings are added as fast as the top is sunk to the floor level, until the required depth is reached. The tank is then completed by putting in the bottom and the top, and rusting the joints with a mixture of iron filings and sal ammoniac calked in place, which gives a joint impervious to steam or water. By sinking them below the floor line and bringing the manhole opening and cover up to this line, all pipe connections to these tanks can be made beneath the floor. With this construction no brick pit is required, as the plates are sufficiently heavy and strong to withstand the external pressure, and as only the exact diameter of the tank is excavated, there will be no settling. Being sectional, they can be introduced into any building through the regular doorways or openings."

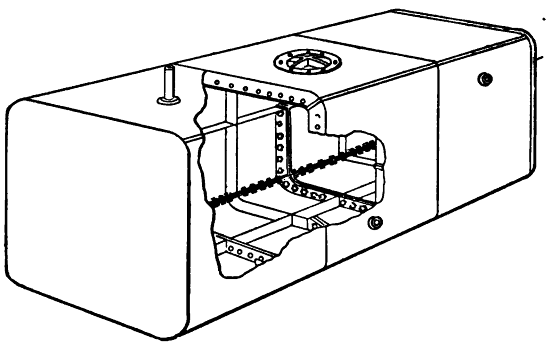


FIG. 142. — Cast Iron Drip Tank

House pump governor

Fig. 143 shows a common type of tank pump controller for automatically starting the steam pump whenever water is drawn from tank or standpipe and stopping the pump whenever the water reaches a given height, thus keeping the tank constantly filled with water up to any point that may be desired and preventing overflowing. When the ball float is raised by the water the valve is closed and the action of the pump increases the pressure in the discharge line, this pressure acting on the diaphragm of the regulator overcomes the compression of the spring and closes the valve. When the water line in the tank falls the action is reversed.

The check valve shown in Fig. 143 opening toward the pipe is of use in case the vertical supply line from pump to tank has branches to supply fixtures. It is better practice to supply all fixtures through a separate discharge line from the tank, but in certain cases especially in manufacturing plants a considerable saving can be made in piping by using the line connecting the pump with the tank for both a supply to and discharge from the tank. With this arrangement the pressure in this pipe varies and there is more or less shock on fixtures, due to the action of the pump. It is well to place a stop valve in the small pipe connection with the regulator, and to place a by-pass around the latter in plants of some magnitude.

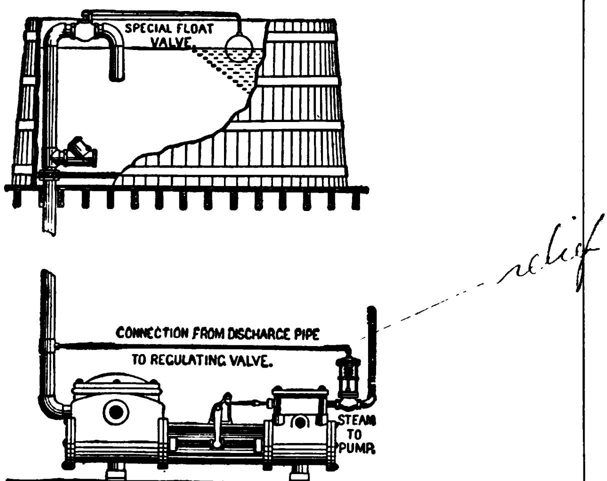


FIG. 143. — Arrangement of Tank Controller for Pump

Boiler Feed Governor

Fig. 144 shows a pump regulator with by-pass connections and lubricator.

This regulator automatically maintains the proper pressure on the boiler feed line, the mere action of a feed valve near the boiler causing the regulator to operate.

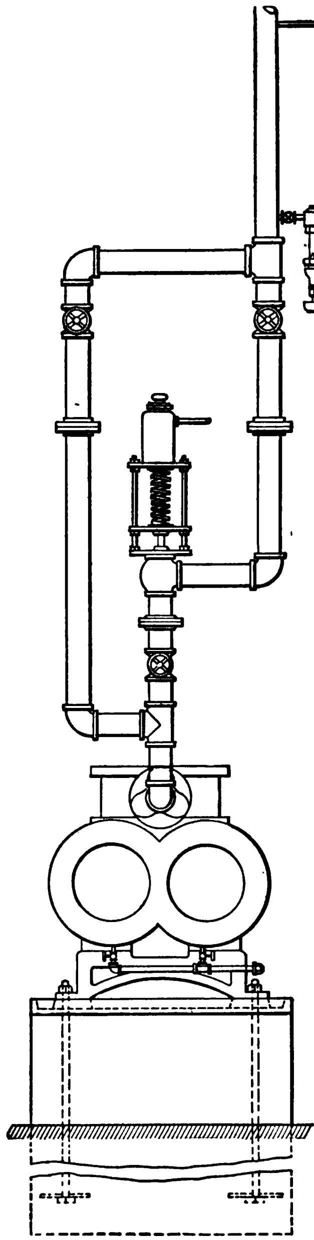


FIG. 144. — Steam Pump with Automatic Regulator

Fig. 145 shows a rather neat arrangement of steam connections with a pair of boiler feed pumps as noted in a large power plant. The pump regulators are flanged to provide for ready removal in case of repairs. The small pipes leading from the top of these connect with the boiler feed line, and these connections are valved. Drip connections may well be placed just above the by-pass valves, although if these are opened slowly after a period of disuse the water may be allowed to pass off through the pumps. In this case the cylinder lubricators were connected directly with the steam chests at the top. A lubricator could well be connected with the vertical steam supply pipe to take the place of these or force feed lubricators could be used.

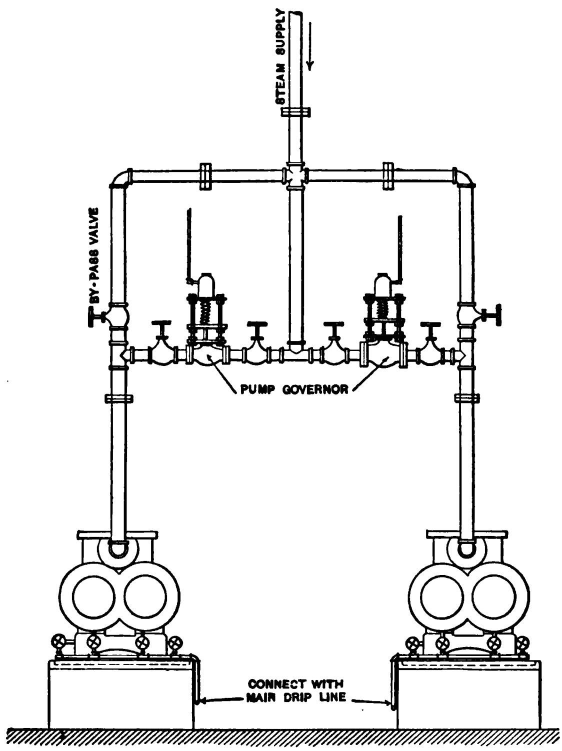


FIG. 145. — Pair of Boiler Feed Pumps with Regulators

Except in the case of pumps having the suction connection with but a single supply and the discharge leading directly to boilers or to a tank, there is good opportunity for the fitter to display some originality and skill in the arrangement of pipe connections. Several methods of arranging the piping are shown in the illustrations presented herewith.

Fig. 146 shows by a combination of plain elevational and isometric drawing one method of piping a pair of boiler feed pumps to be used interchangeably as house service pumps. The suction of each pump is provided with valved connections with (1) the feed water heater, (2) the city water supply and (3) a large concrete reservoir below grade. The branch discharge lines lead to (1) the boiler (2) the house service tanks (3) the sprinkler system tanks and (4), in the case illustrated, to the dye house storage tanks placed at a lower level than the house service tanks.

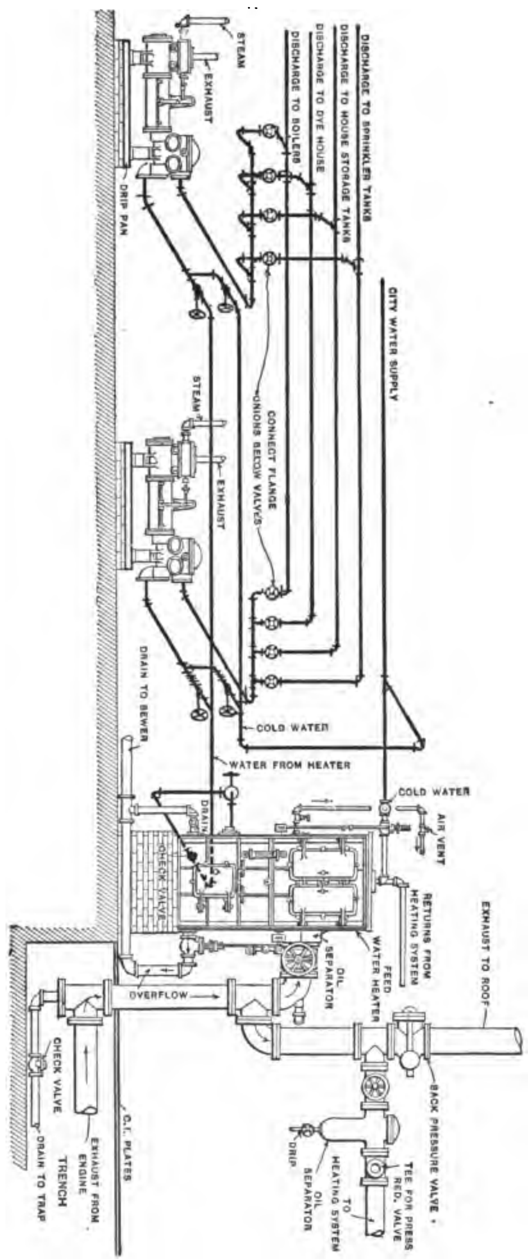


Fig. 146. — Pump Connections

Fig. 147 shows a typical pump layout for an office building, the pumps being supplied either from the feed water heater or direct from the connection with the city main. The discharge lines lead to the boilers and to the house service tanks in the attic or on the roof, the tanks being provided with a float valve at the end of the discharge line. This valve should be of the balanced type.

A pump regulating valve is shown in the cut for controlling the speed of the pump when operating on house service. When used for boiler feeding the pump is controlled by hand through the by-pass.

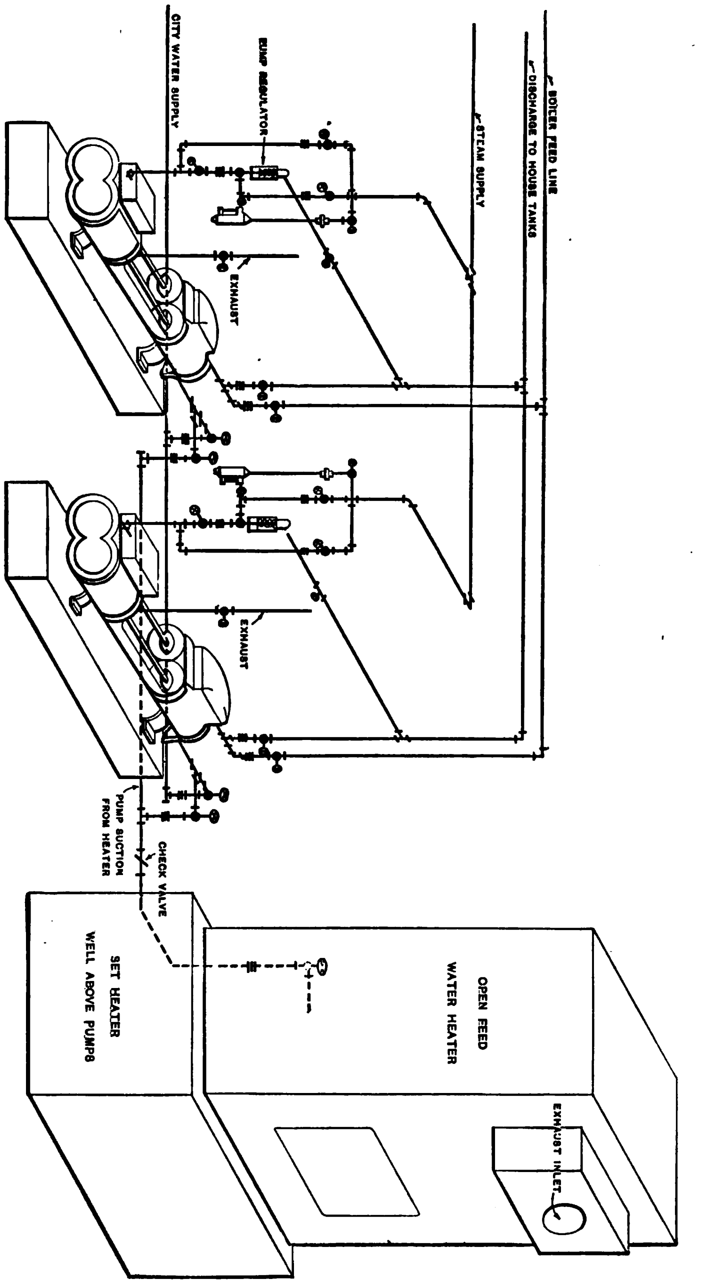


Fig. 147. — Pump Connections

Fig. 148 shows three pumps all proportioned for boiler feeding connected so that any pump can draw its supply from the city main, from the filtered water tank or from the feed water heater. A direct city water connection is also provided for filling the boilers. The discharge connections lead to (1) the boilers, (2) the house service tank for filtered water, (3) the house service tank for unfiltered water, (4) the sprinkler system tank. The arrangement indicated provides for the use of one pump for boiler feeding, one for house service and one spare. The drawing, a combination of isometric and plain elevational, illustrates a simple method of conveying to the fitter the ideas from the office as to the general arrangement of piping desired, the pumps being indicated as shown instead of as they really appear, in order to save time in making the drawing. The latter serves the purpose as well as if the pumps were drawn out in the greatest detail. Single lines serve to show the piping as well as though double lines had been used.

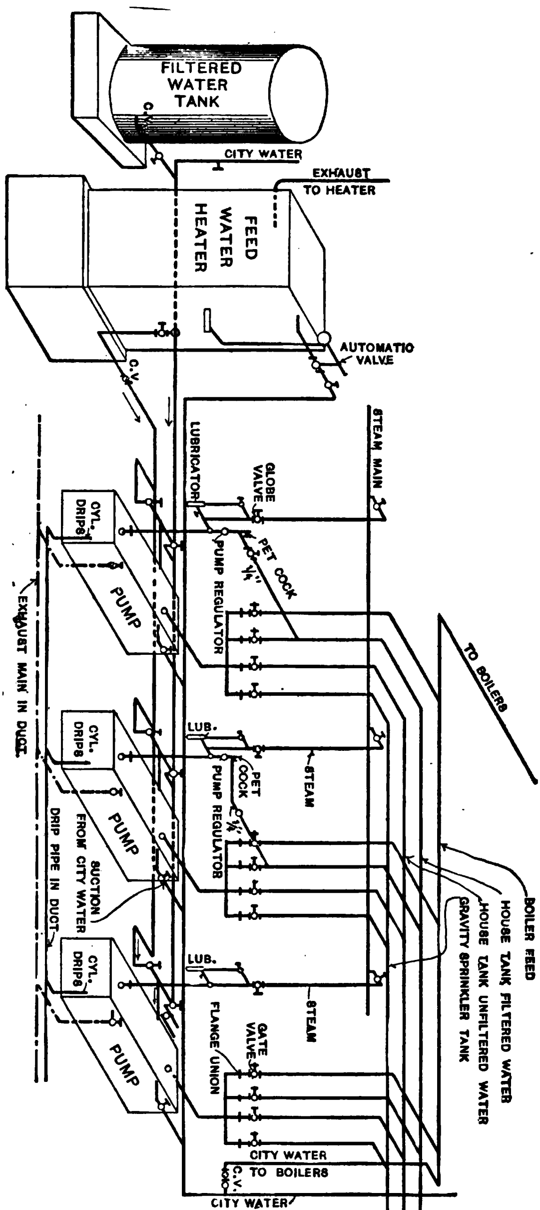


Fig. 148. — Pump Connections

Vacuum pump governor

Fig. 149 shows a common arrangement of receiving tank, automatic pump regulator, etc., which may be used in connection with both low and high pressure returns, provided the tank is vented.

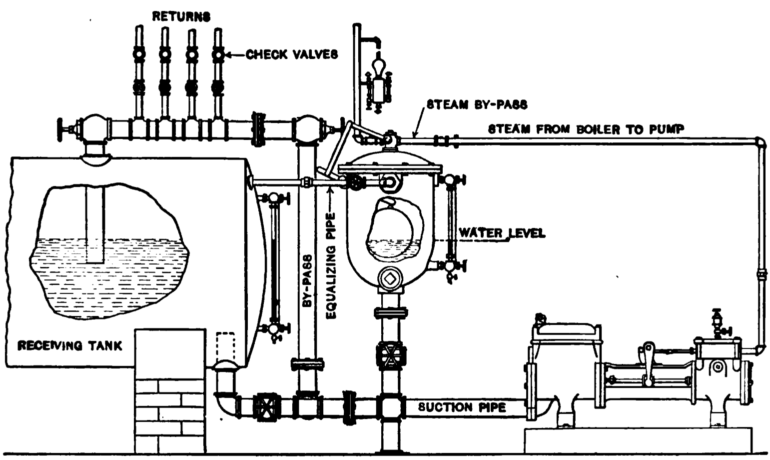


FIG. 149. — Pump Regulator Connections

Fig. 150 shows one method of connecting a pair of pumps (one to be used as a relay) with a tank into which the returns from a large heating system discharge. The tank should be so set that there will be a good head of water above the suction valves of the pumps. The pumps are arranged to be operated by hand in case the pump controller is temporarily out of commission.

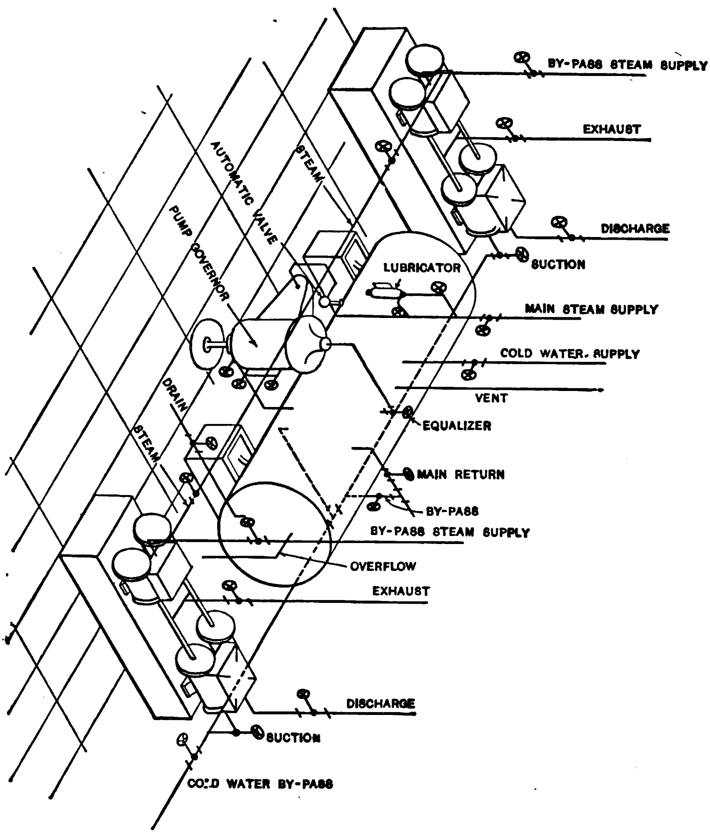


Fig. 150. — Pump and Receiving Tank Connections

Fig. 151 shows a double cylinder damper regulator used to operate balanced valves when a very close regulation is desired between live and exhaust steam.

One piston is more heavily weighted than the other.

When pressure reaches the desired point in line to heating system or machines the diaphragm is raised, lifting the weighted lever and admitting water pressure to the two cylinders. The one more lightly weighted rises first and shuts the balance valve, cutting off live steam to the main pipe, the back pressure valve remaining closed. Should the pressure increase after live steam has been shut off, the heavier weights are then raised by the water pressure and the large balanced valve is opened, permitting a portion of the steam to escape to the atmosphere.

Should this pressure now fall the heavy weights fall first, closing the back pressure valve and should the pressure fall still lower the lighter weights descend, opening more or less as may be necessary the balanced valve, admitting live steam to the system.

Single cylinder combination regulators are not infrequently used for operating either a large size balanced valve for back pressure service or a high pressure balanced valve for reducing pressure service.

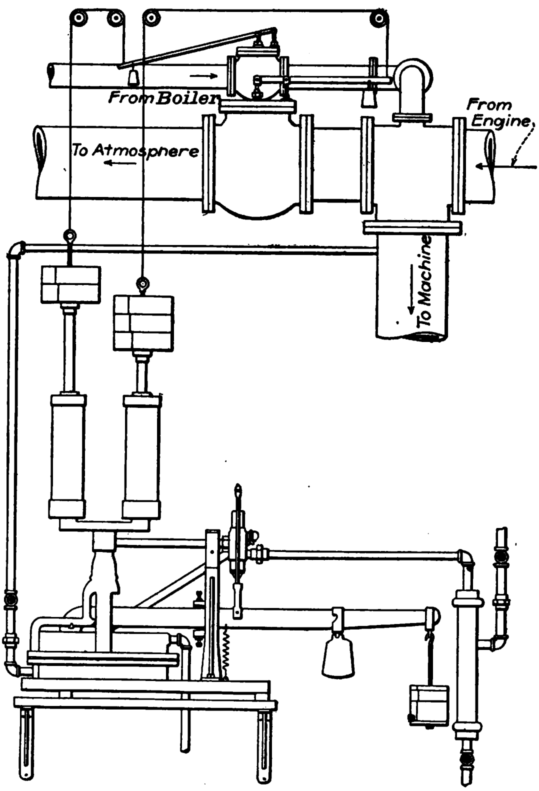


FIG. 151

Figs. 152 and 153 show oil separators with siphon loop and with trap. If there is any chance of the pressure in the oil separator falling below atmosphere the trapped discharge is preferable, provided the trap can be set several feet below the bottom of the separator. With the siphon loop arrangement, if the point of discharge can be placed only 2 feet or thereabouts below the bottom of the separator, it requires comparatively little vacuum to hold greasy water back in the separator, some of which is likely to find its way to the boiler and cause trouble. For condensing plants the oil separators are arranged to discharge to a tight tank which may be emptied periodically, or to some form of automatic pump and tank arrangement.

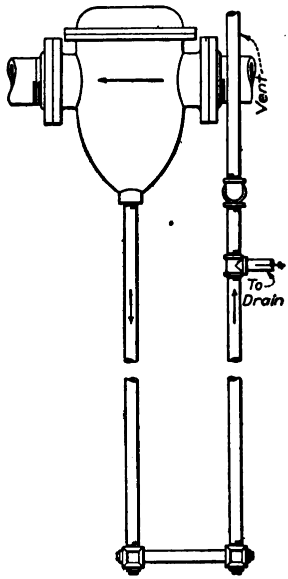


FIG. 152

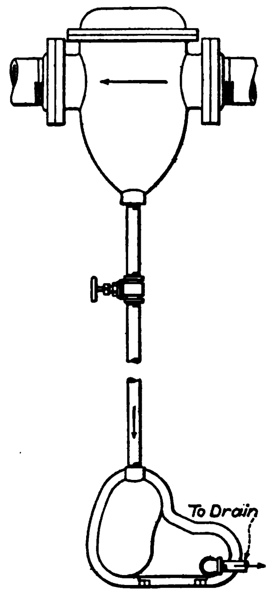


FIG. 153

CHAPTER IV

Drawings of Piping and Apparatus

Much labor can be saved and drawings can be finished with great convenience, accuracy and promptness if the method here explained is adopted in laying out heating work. It comprises in substance the preparation of charts from which the leading dimensions of any size radiator, valve, fitting or other standard piece of apparatus used in heating work can be readily transferred to the drawing in question. Besides facilitating the production of drawings, there are many instances where the complexity of the plans or the close utilization of space is such that the utmost care needs to be exercised in arranging for the apparatus in order that there may be no attempt to put two things in the same space. The charts described, prepared by the author, are based on the actual dimensions of the parts of a heating system mentioned and are designed so that the draftsman can transfer the dimensions without need for proportional dividers or scale rule.

Radiators

Fig. 154 is designed to avoid constantly referring to catalogues for dimensions of radiators when laying them in to scale on drawings. The chart given is merely typical and in this case is for three column radiators of a well-known make. Other similar charts are used for single column, two column and four column radiators. In Fig. 154 which is drawn to a scale of $\frac{1}{4}$ in. to the foot, the distance horizontally from the vertical line A B to the several lines marked 18 in., 22 in., 26 in., etc., represents the length of radiators of different heights of the surface stated in the column at the

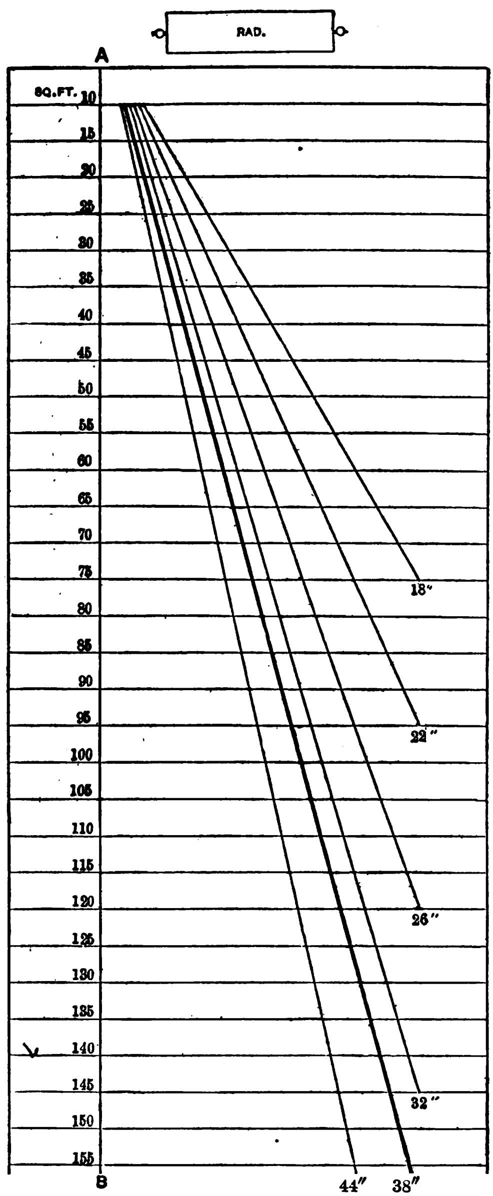


FIG. 154. — Dimension Chart for Three Column Radiators
Scale, ¼ in. to the foot

left. The line for 38 in. radiators is made heavier than the others, as it is most often referred to, corresponding as it does to radiators of standard height.

The width of a three column radiator is represented by the figure at the top of the chart. Common distances to allow for space occupied by angle valves are as follows:

1 in. valve	4 in.
1¼ in. valve	4½ in.
1½ in. valve	5½ in.
2 in. valve	6 in.

If the radiators are bushed add ½ in. for each bushing.

To illustrate the use of the chart, suppose it is desired to lay out a 120 sq. ft. radiator 38 in. high. Take a pair of dividers and on the horizontal line just below the number 120 take the distance from line A B to the heavy line marked 38 in. Prick this distance on the plan in the desired location, after the manner shown in Fig. 155, and for the width take the distance across the radiator shown in plan at the top of the chart. The radiator should be marked on the plan 24 s — 3 c — 38 in. = 120 sq. ft. for example, meaning 24 section, 3 column radiator 38 in. high.

With drawings having radiators so indicated it is a simple matter for men to properly distribute them. It is well to state the square feet of surface in each radiator for convenience in estimating, using the conventional sign ☐ to represent square feet.

The scale of the chart must of course agree with that of the drawing. Charts drawn to scales of $\frac{1}{8}$ in. and $\frac{1}{4}$ in. to the foot will correspond with the common scales used by architects. The time spent in preparing such charts for radiators commonly used by a given concern will be quickly repaid by the greater convenience they afford over the common method of consulting catalogues for the necessary dimensions.

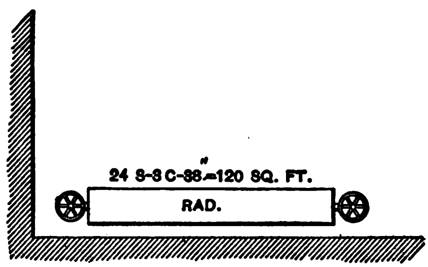


FIG. 155. — Plan of Radiator, showing Application of Chart

Fig. 156 is drawn to the scale of $\frac{1}{2}$ in. to 1 ft., a scale that shows most piping very clearly. Charts drawn to other scales may very easily be prepared from this one, those to the scale of $\frac{1}{4}$ in. to the foot being specially useful when working on architect's drawings. Such charts are great labor savers over the common method of referring to trade catalogues for these dimensions, and will doubtless suggest the making of dimension charts of other materials or apparatus frequently shown on drawings in different lines of engineering work.

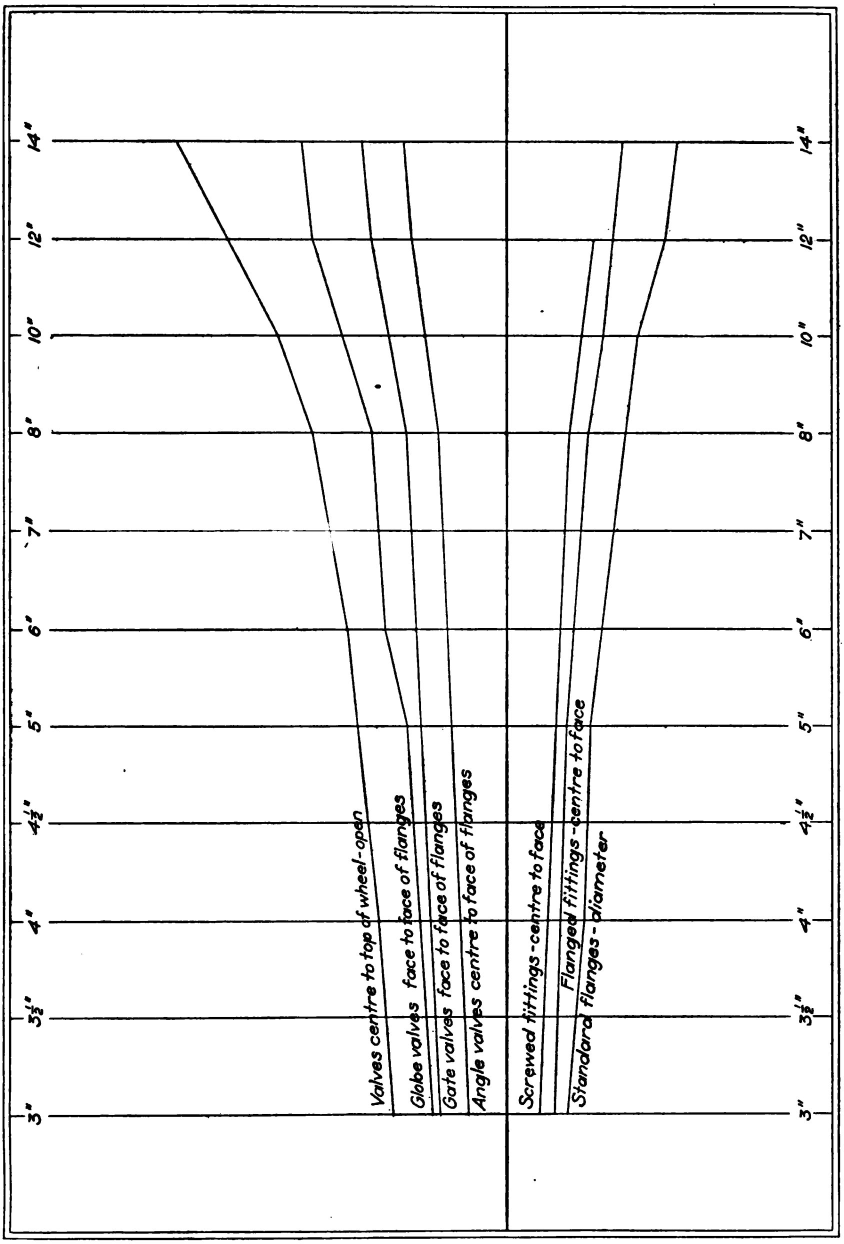


FIG. 156.—Dimension Chart for Valves, Fittings and Flanges. Scale, ¼ in. to the foot

NOTE.—The distance from center to top of wheel for gate and globe valves is so nearly the same in some makes that only one line is shown in the chart for both.

Piping, Valves, Fittings

Fig. 156 will be found of great convenience in the office of the engineer or contractor in laying out piping, with fittings and valves. The chart is practically self-explanatory. A pair of dividers should be used, with which take the distance from the horizontal line to the line representing the valve, fitting or flange desired. For example, to lay off a standard 10-in. flanged tee with elbow on one side and a gate valve on the other, as shown in Fig. 157, take the distance on the vertical line marked 10 in., from the horizontal line to the one marked flanged fittings — center to face — and lay off A, B and D. Then lay off C and E in the same manner by referring to the proper lines on the chart. The valve is shown in the conventional way by an X, and the location of the valve wheel is indicated.

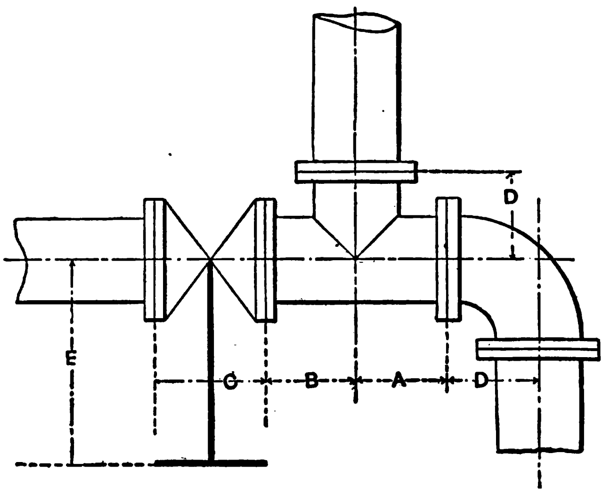


FIG. 157. — Application of Chart No. 2 to Drawings.
Scale, ½ in. to the foot

Fig. 150 serves to show the clearness with which the arrangement of all apparatus and piping may be shown in one view by means of an isometric drawing. By this method the horizontal lines of an object are drawn to scale at an angle of 30 degrees with the horizontal. The vertical lines of the object are so indicated on the isometric drawing, also to scale. To fully represent by regular mechanical drawing a box 2 × 3 × 6 ft., for example, would require three views, plan, side or front and end elevations. It could be shown equally well if not better by an isometric drawing as illustrated in Fig. 158. To draw a circle isometrically, inscribe it in a square the sides of which are of the same length as the diameter of the circle, then connect the points midway of the length of each side by a curved line, as illustrated in Figs. 159 and 160. This rule is useful in drawing cylinders, valve wheels, fittings, etc. This method of drawing is somewhat harder to acquire than the three-view method, but is far easier for workmen to comprehend.

The writer once had this illustrated when he was sent for by the operator of a pipe cutting machine, to whom had been given a drawing of some large pipe connections, shown in plan, elevation and side view. The writer endeavored to explain what was required, but the workman insisted on having the piping sketched out either "on the flat" or by the method just described, saying that if he could understand the kind of drawings first presented he would not be running a pipe machine; which emphasizes the desirability of having all work of this kind clearly drawn, so that the intent of the sketch can be taken in at a glance by the workman. Always make sure that the drawing supplemented by notes includes all the ideas it is intended to convey, so that additional verbal explanations will be unnecessary.

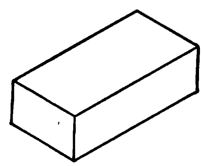


FIG. 158

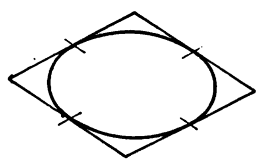


FIG. 159

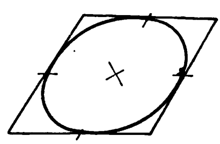


FIG. 160
Group of Isometric Drawings

Figs. 161 and 162 and Fig. 163 illustrate further isometric drawing, the latter being developed from the front and side elevations of a feed water heater as illustrated in the two figures first mentioned. In Fig. 163 the merest outlines have been shown in order to illustrate the method and to show how the flanges appear when shown isometrically. It is often puzzling to the beginner how to show circles isometrically. It is hoped that illustrations, Figs. 159, 160 and 163, will be of assistance.

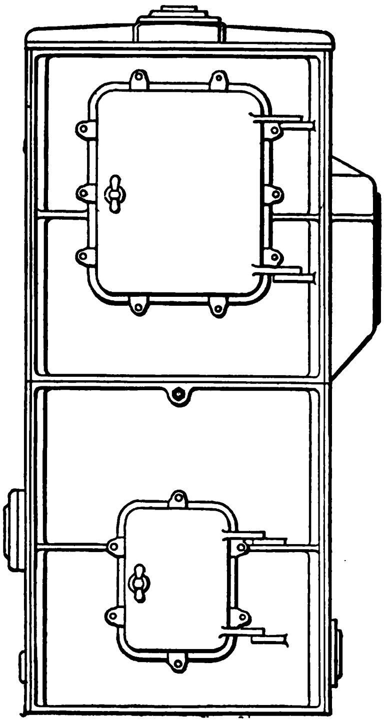


FIG. 161. — Front View Feed Water Heater

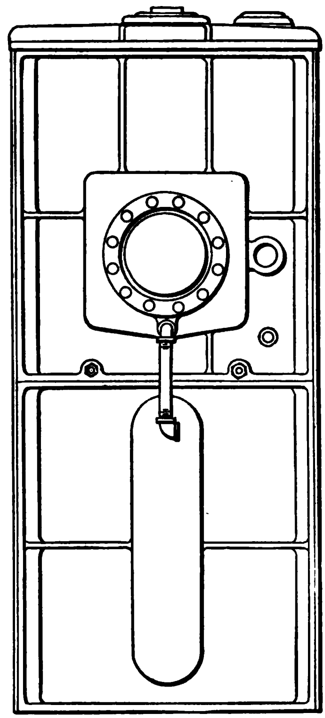


FIG. 162. — Side View Feed Water Heater

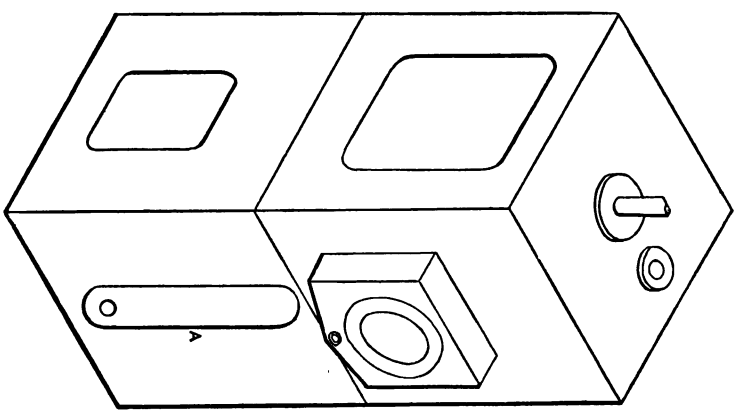


FIG. 163. — Isometric View Feed Water Heater

To illustrate the use of Figs. 159 and 160, Fig. 165 is presented. The top and end flanges shown in Fig. 164*a* are developed isometrically, the points *a*, *b*, *c*, and *d* in these figures corresponding. The same is true of points *e*, *f*, *g*, and *h*, shown in Figs. 164*c* and 165. The distance from the center to all these points is the same. The face to face dimension measures the same in Figs. 164*a* and 165.

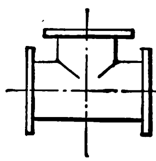


Fig. 164*b*
Side Elevation,
Tee

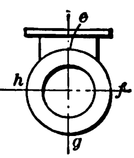


Fig. 164*c*
End Elevation,
Tee

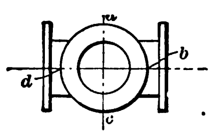


Fig. 164*a*
Plan, Tee

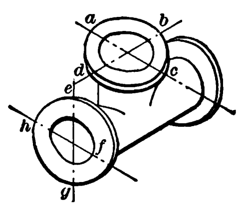


Fig. 165
Isometric, Tee

Plans intended to show boiler, engine and pump connections, etc., can hardly be drawn with much clearness to scale smaller than $\frac{1}{4}$ in. to the foot, although with the single lines shown in Fig. 166*b* very good results can be obtained on $\frac{1}{8}$ in. scale drawings. It is well to use two and sometimes three plans, according to the complexity of the system, one for the overhead piping, one for the piping near the floor and one for underground pipes. Two of these may be combined for simple layouts, but it is confusing to attempt to show all the pipes on a single plan. The pipes for different services are represented by lines varying in character, a key being placed on the drawings to identify them. Different engineers use different keys, no standard, so far as the writer is aware, having been adopted.

Fig. 166*b* shows a series of lines used by the writer which were found pretty satisfactory in practice. In connection with the single line drawings, based on Fig. 166*b*, stop valves may be shown either like A in Fig. 166*a* for flanged valves and B for screwed ones, or they may be shown with the wheel, as in C. Swing check valves may be shown as in D and globe check as in E.

The single line drawings are recommended for general layout and estimating purposes, it being more satisfactory to make the working drawings showing large pipes with double lines spaced the diameter of the pipe apart with fittings drawn in with face to face dimensions and flanges to scale. See Fig. 156 for dimensions of valves and fittings.

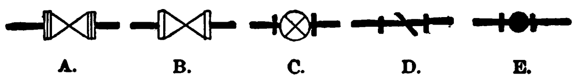


FIG 166*a*

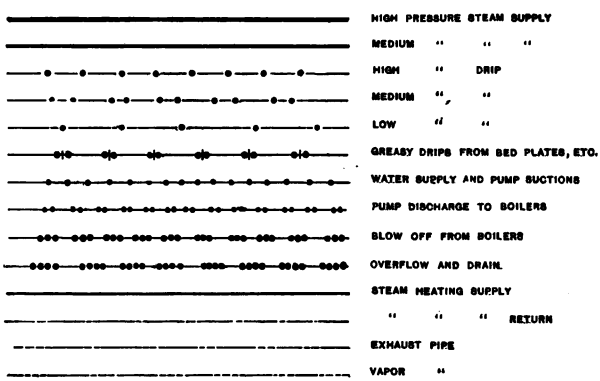


FIG. 166*b*

CHAPTER V

GALVANIZED IRON WORK

This chapter treats of various methods commonly employed in the construction of ducts and flues used with the fan systems of heating and ventilation, and will take up details of dampers, hangers, etc. Tables of the weights of round and rectangular pipes will be given, together with extracts from specifications dealing with gauges and methods of construction. Although such work is used chiefly with fan systems the following will apply equally well to large gravity systems:

ROUND PIPES

Longitudinal seams in round or oval pipes are generally made with the usual lock edges, as shown in Fig. 167*a* on all gauges up to and including No. 20 iron. After the edges are locked the pipe is placed on a mandrel and the seam is set down with a hand groover of the proper size and is then set down flat with a hardwood mallet, making a finished seam, as shown in 167*b*. The cost of these operations can be materially reduced if one of the various styles of hand or power machine groovers now on the market is used. Pipe jointed in this manner meets all the requirements of a first-class job and does not need additional soldering.

Piping of No. 18 and heavier gauges should be made with riveted lap joints. Rivets should be spaced about 2 or 2½ in. on centers, and buttoned down on surface of metal with a rivet set of proper size. The total lap should never be less than 1 in., as shown in Fig. 168.

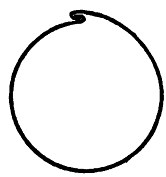


FIG. 167a

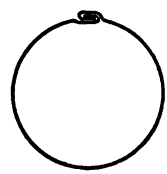


FIG. 167b

FIG. 168

Round Pipes — Ring Seams

Figs. 169 and 170 show two methods of making joints in round or oval piping, and can be either soldered or riveted, as desired. Fig. 169 shows a single bead on the small end of the joint, which is made to fit snugly in the large end of adjoining joint of pipe. Fig. 170 shows a bead on the small end of joint fitted to the large end of the adjoining joint. These beads serve to stiffen the pipe, and sometimes several are used close together for this purpose.

Fig. 171 shows a plain lap joint, having a lap of about 2 in., and can be either soldered or riveted, or both, as required. Joints are marked out allowing for an outside diameter on small end of joint and inside diameter on the large end of joint. When the proper allowance is made the small end should make a tight joint with the adjacent one, when the lap allowed has been reached.

Fig. 172 shows a method of using either cast or wrought angle iron flanges in making up joints on piping of heavy gauges or piping run in a vertical position on the exterior of a building. Angle iron flanges are generally riveted on each end of a length of piping, about 12 or 14 ft., which has intermediate riveted lap joints.

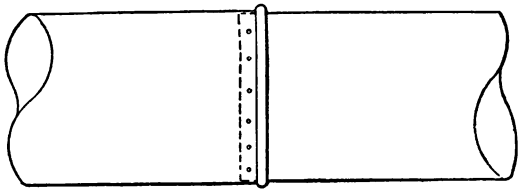


Fig. 169

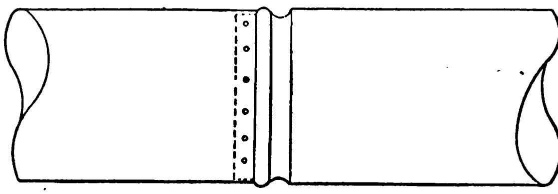


Fig. 170

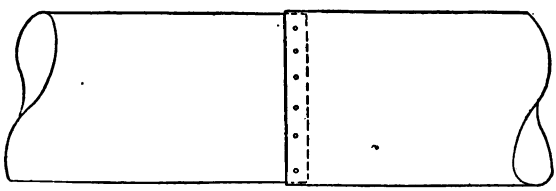


Fig. 171

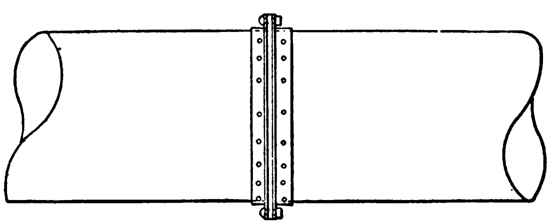


Fig. 172

Galvanized Iron Work for Fan Systems

Fig. 173 shows a special flanged connection used on work that must be absolutely tight. Special angle flanges are recessed at A to receive the ends of the pipe section, which are flanged over. A collar about 3 in. long, made of a straight piece of iron rolled to diameter of the flange, is riveted to the small end of the pipe and extends beyond the joint. Such joints are used on pressure work, but are not required for ordinary heating and ventilating systems.

Elbows, Branches and Tapers

Elbows should have the internal radius at least equal to the diameter of the pipe with which they connect. Even in the smaller sizes they should be made up of not less than five pieces, those about 8 in. usually having seven pieces. See Fig. 174. All elbows, except those of No. 18 gauge and heavier, are grooved and locked. Heavier elbows are riveted and soldered.

In blower work of good construction the branches are carefully designed somewhat as shown in Fig. 175.

Tapers to reduce from one size to another are generally made in a length of not over 36 in. They are either straight or offset to suit conditions.

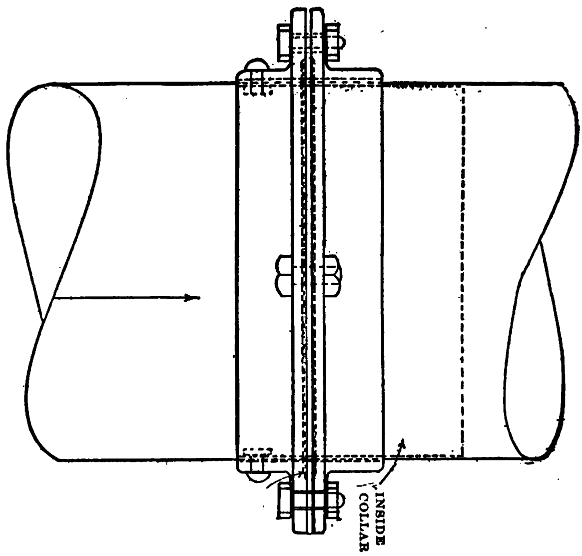


FIG. 173

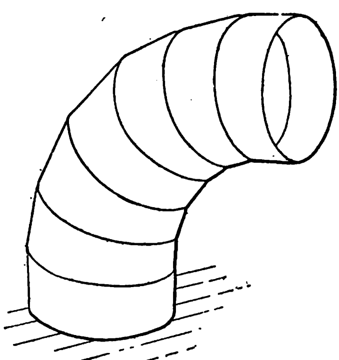


FIG. 174

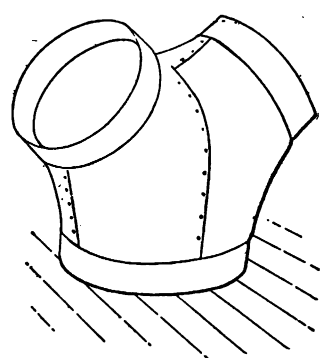


FIG. 175

Galvanized Iron Work for Fan Systems

LONGITUDINAL SEAMS IN DUCTS

Longitudinal seams on rectangular piping are made in various ways, and should be modified to meet the conditions of cutting sheets to make the various sizes of piping, also to suit the means of handling various sizes of piping in the shop.

Fig. 176 shows one of the most common ways of making a longitudinal seam. This is done by bending the single edge at right angles to the piping. The double edge is turned over and locked over the single edge, and the single and double edges are then bent over flat as shown.

Fig. 177 shows another method of making longitudinal seams which is very popular in many shops; this is simply the ordinary groved seam, and can be located at whatever point desired. This is an advantage, since the sheets can then be cut with a minimum of waste material. The seam is made in the manner described for round pipes. Where a hand or power machine groover is available, these joints can be made very quickly and at small cost, especially when piping is made up in 8 ft. 0 in. joints. When large sizes of pipes are to be shipped to a distance, they can be made up in this manner, with seams left open during shipment to be put together by hand on the job. This facilitates handling, permits nesting during shipment and saves in the cost of transportation. Less damage is likely to occur during shipment than where the pipe is shipped made up.

Sheets can be taken from the bundle of iron, squared up in the shears and then taken to the cornice brake and edged on both sides, also making the right angle bend all at one handling. This method can be used on all gauges up to and including No. 18, if the iron used is of a good grade. If poor iron is used it would be wise not to make this seam on gauges over No. 20, as when edges are turned over in the brake they often crack open, and the whole piece must then be taken out, a costly proceeding.

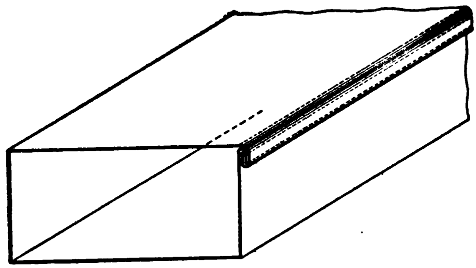


FIG. 176

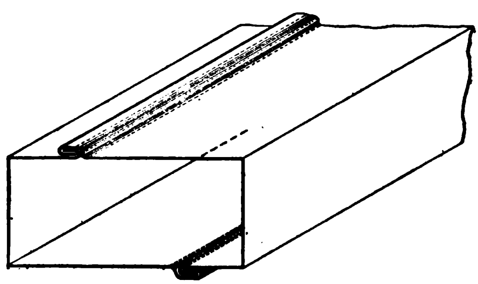


FIG. 177

Longitudinal Seams in Ventilating Ducts

Fig. 178 shows the method of making longitudinal seams on piping of heavy gauges. They are ordinary lap seams and can be placed in almost any position. The lap on these seams should never be less than 1 in. and rivets spaced about 2 or $2\frac{1}{2}$ in. on centers, and in about $\frac{1}{2}$ in. from side of sheet, making rivet line in center of lap. When an especially neat job is required, regardless of expense, it is probably better to make the lap at the corners of the pipe, as shown in Fig. 179 and place the lap on the inside. The raw edge of metal can be rounded over the corner, making a very neat and serviceable job. Riveted joints should be made up very carefully and rivets buttoned down on the metal with a rivet set of the proper size.

Fig. 180 shows a general method of constructing ducts of heavy plate metal when metal is too heavy to readily make a right angle bend on a sheet of ordinary length. Angle irons about $1\frac{1}{2}$ — $1\frac{1}{2}$ — $\frac{3}{16}$ in. are cut the exact length of sheets, and about $\frac{9}{32}$-in. holes punched about 3 in. on centers.

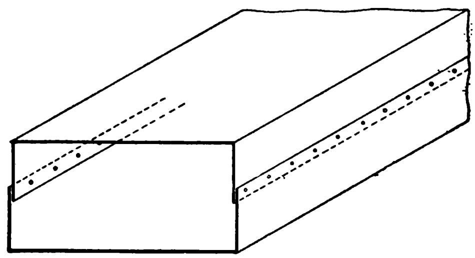


Fig. 178

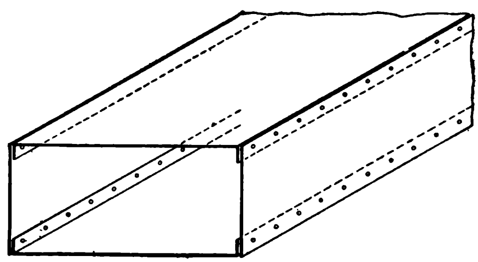


Fig. 179

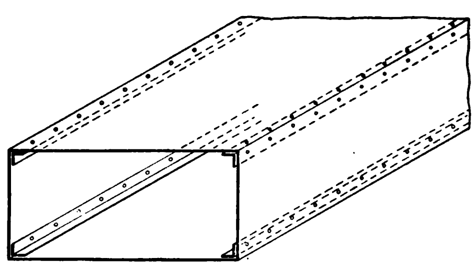


Fig. 180

Longitudinal Seams in Ventilating Ducts

Girth or Circular Joints for Rectangular Ducts

The following shows approved methods of making up joints of rectangular piping into lengths as occasion requires:

Fig. 181 shows a method of making up joints for the lighter gauges of iron, say from No. 30 to No. 26, and is known as a double seamed joint. A single edge is turned up on one end of the joint of pipe, and a similar edge on the abutting end is slipped over it. Then both edges are brought over flat with a smooth mallet. This seam should be dented by means of a good prick punch in order to avoid the joint slipping out while handling the finished length.

Fig. 182 shows a joint much used on good work and known as the slide joint. Edges are bent almost flat on the pipe, and a double edged flat piece is slipped over these edges. This makes a very neat and serviceable job, and has the advantage of being utilized in almost any tight corner, besides enabling the duct or casing to be taken apart for cleaning.

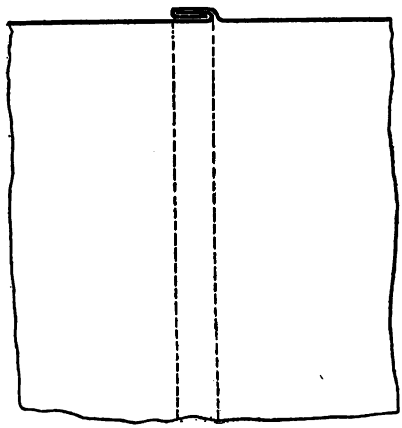


Fig. 181

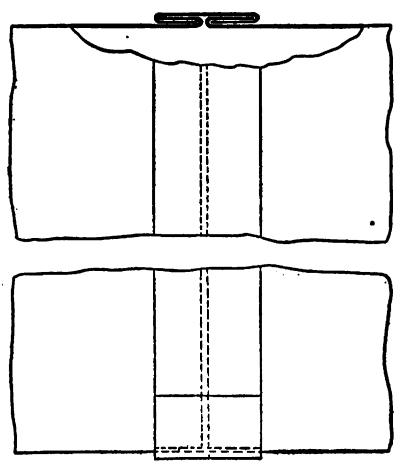


Fig. 182

Girth Joints for Rectangular Sheet Metal Ducts

Fig. 183 shows a form of slip joint used where particularly neat work is required. The slip proper is made up separate from the piping, and outside edge wired with about $\frac{3}{16}$ or $\frac{1}{4}$-in. round rod, then formed up with solid corners and riveted to small end of the duct, where provision has been made for its reception by cutting out the corner of the duct for the length of the slip. Then the large end of adjoining joint is placed into this slip as shown. Slips of this character should not have less than 2-in. lap, and outside section of slip should be about 1 in. wide.

Fig. 184 shows the same pattern of slip joints as the foregoing, but without the wired outside edge, and in place of it a hem edge turned inside of slip, thus doing away with the raw edge of metal that would otherwise be exposed.

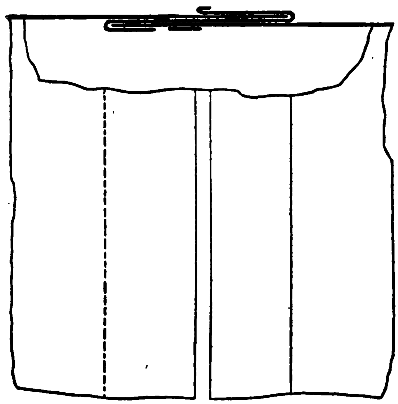


FIG. 183

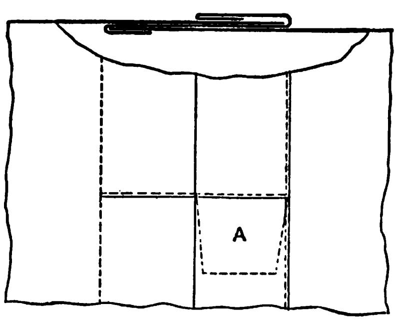


FIG. 184

Girth Joints for Rectangular Sheet Metal Ducts

Fig. 185 shows a joint used by some blower manufacturers for their rectangular ducts. The sleeve B, into which the end of section C slips, is about 2 in. long. This joint gives the appearance of good workmanship in a system of ducts connected by this method.

Fig. 186 shows a method of making up joints that has been used where a very neat job is desired. About $\frac{3}{8}$-in. edges are bent up at an angle of 45 degrees on large and small ends of the piping. They are then placed together and a $\frac{1}{2}$-in. brass tube previously slotted is slipped over the edges, mitering the corners of the tubing. This method of making joints is often used for cylinder lagging.

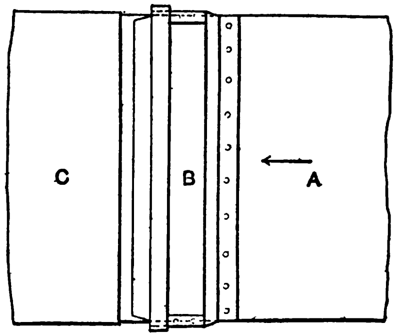


FIG. 185

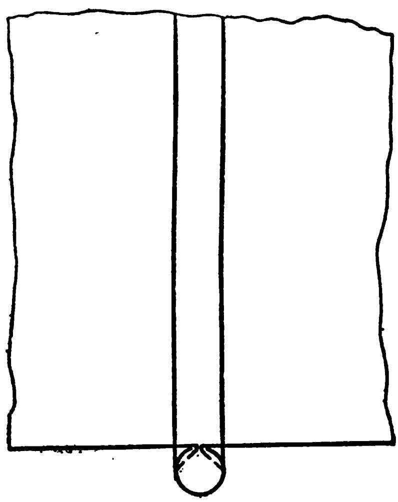


FIG. 186

Girth Joints for Rectangular Sheet Metal Ducts

Figs. 187 and 188 show a joint used on large rectangular piping. This joint is practically a standing seam joint, makes a strong, firm joint and also serves to stiffen the piping. When these joints are made about 36 in. long it makes a very rigid length of piping without the additional bracing generally necessary on piping of large sizes. The joint is made by bending a single edge about 1 in. at right angles to the side of the piping, and on the adjoining edge a double edge is bent, bending down nearly tight on three sides of the duct, allowing one side open in order to slip single edge into position. Then all sides are gone over and hammered down tight and riveted or bolted through the standing lock.

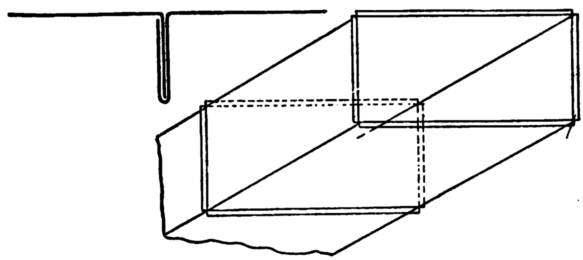


Fig. 187

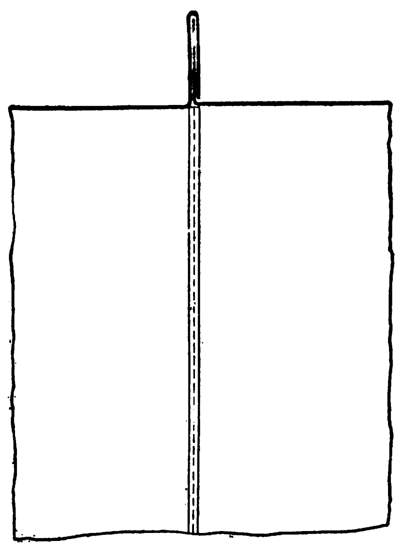


Fig. 188

Girth Joints for Rectangular Sheet Metal Ducts

Fig. 189 shows angle irons arranged to make a joint between lengths of piping. The angles should be either 1, $1\frac{1}{4}$ or $1\frac{1}{2}$ in., according to the size of the pipe. They should be riveted securely, making either a miter or butt joint on the corner of the piping.

Bracing of Rectangular Ducts

On rectangular ducts having a width of about 30 in. or over it is generally necessary to provide some means of bracing the wide sides of the ducts. Fig. 190 shows a popular and cheap method of bracing with bar iron braces, suitable to use on ducts up to 36 in. wide. Braces can be made of about $1\frac{1}{4} \times \frac{3}{16}$-in. bar iron and bent up in Z form, as there is no tendency for the brace to turn sideways. Only one rivet is used on each end in riveting to duct.

Fig. 191 shows a method of bracing ducts by means of bent strips of about No. 18 iron, riveted to the ducts as shown.

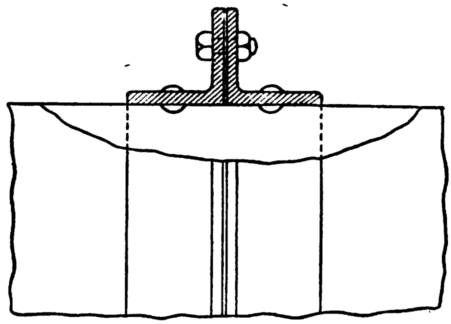


Fig. 189. — Girth Joints for Rectangular Sheet Metal Ducts

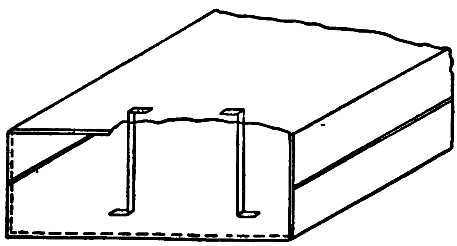


Fig. 190

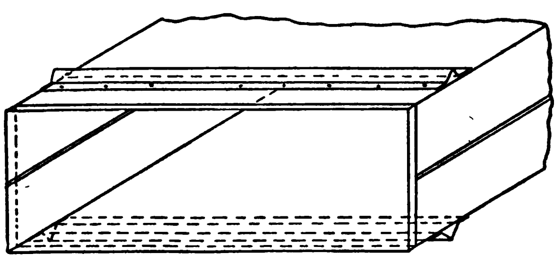


Fig. 191

Bracing Rectangular Ducts and other Details

Fig. 192 shows a duct braced with angle iron, which makes a thoroughly substantial job. Angle iron should not be less than $1 \times 1 \times \frac{1}{8}$ in. on ducts up to 40 in. wide, and using larger angle iron on sizes above this. Rivets should be spaced about 6 in. on centers and braces spaced about 32 in. apart.

Fig. 193 shows a method of using wooden strips incased in galvanized iron and fastened to the ducts by wire nails, clinched on the inside. Strips of hemlock or almost any soft wood, about $2\frac{1}{2} \times \frac{7}{8}$ in., with the ends tapered wedge shaped for a distance of about 4 in., are completely incased in a covering of about No. 26 galvanized iron, allowing a small tab for riveting to the side of the duct at each end of the brace. The rough edges of the iron are left on the underside of the brace, which is then set on the duct and 3-in. wire nails are driven through the brace and duct, then clinched over by the helper on the inside. This makes a cheap form of bracing, but is barred out by many specifications.

Fig. 194 shows a very good method of bracing rectangular ducts, and can be used on all sizes. Angle irons are cut for all sides, and an allowance equal to the width of the angle iron is made on each angle on each end. By setting angle irons on adjacent sides of the duct in an opposite position, we will have angle irons meeting back to back at the corners, then having a hole in each they can be bolted or riveted together, forming a complete frame around the duct. This feature is made use of in erecting them on a length of piping, as the necessary number of braces can be bolted around the piping, then all riveted to the piping at one time, thereby saving labor in handling. Angle irons should be $1 \times 1 \times \frac{1}{8}$ in. on smaller sizes of piping requiring bracing and $1\frac{1}{4} \times 1\frac{1}{4} \times \frac{3}{16}$ in. on ducts of larger dimensions. Space rivets about 6 in. on centers and space braces about 32 in. on centers.

Fig. 195 shows a method of joining corners of this brace in larger detail.

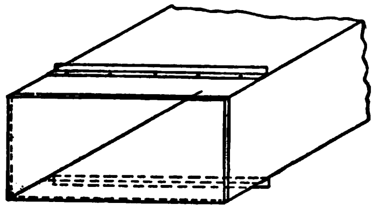


FIG. 192

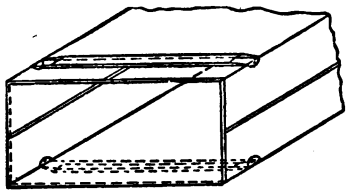


FIG. 193

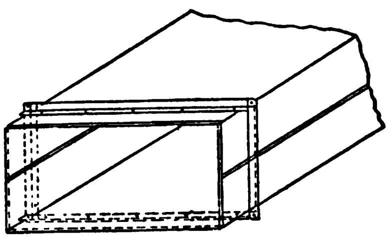


FIG. 194

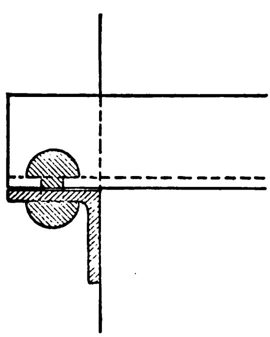


FIG. 195

Bracing Rectangular Ducts and other Details

Transformation Pieces

Transformation pieces are made in a variety of forms from rectangular to square or to a rectangular shape of different dimensions. It is important in the case of the latter that the piece be of ample length, so that the change from one shape to another will not be too abrupt, thus interfering with the passage of air. A transformation from rectangular to round is shown in Fig. 196.

Bends in Rectangular Piping

In making rectangular bends it is always advisable to make them as easy as possible. Good practice determines that bends shall have an inner radius or radius in the throat equal to the diameter of the side of duct in the direction of the bend as shown in Fig. 197.

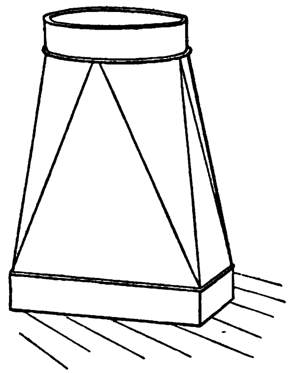


Fig. 196

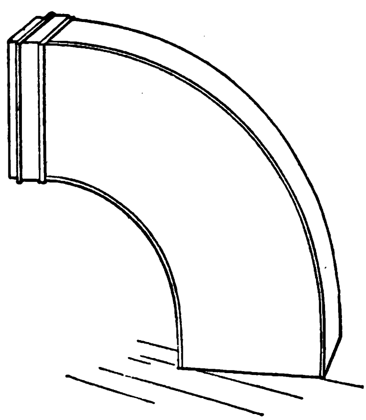


Fig. 197

Bracing Rectangular Ducts and other Details

Gauges of Galvanized Iron

As to gauges of galvanized iron commonly used the following is taken from the United States Government specifications:

Round pipes up to 13 in. in diameter	No. 24 gauge
Round pipes 14 to 30 in. in diameter	No. 22 gauge
Round pipes 31 to 48 in. in diameter	No. 20 gauge

The following are taken from the specifications of prominent engineers:

Round pipes smaller than 12 in.	No. 26 gauge
Round pipes 13 to 20 in.	No. 24 gauge
Round pipes 21 to 24 in.	No. 23 gauge
Round pipes 25 to 30 in.	No. 22 gauge
Round pipes 31 to 44 in.	No. 20 gauge
Round pipes 45 in. and larger	No. 18 gauge
Round pipes smaller than 26 in.	Nos. 24 or 26 gauge
Round pipes 26 to 36 in.	No. 22 gauge
Round pipes 37 to 48 in.	No. 20 gauge
Round pipes 49 in. and larger	No. 18 gauge

One prominent blower company uses these gauges:

Round pipes 3 to 8 in.	No. 28 gauge
Round pipes 9 to 14 in.	No. 26 gauge
Round pipes 15 to 20 in.	No. 25 gauge
Round pipes 21 to 26 in.	No. 24 gauge
Round pipes 27 to 25 in.	No. 22 gauge
Round pipes 36 to 46 in.	No. 20 gauge
Round pipes 47 to 60 in.	No. 18 gauge
Round pipes 60 in. and larger	No. 16 gauge

Weight of Galvanized Iron Sheets in pounds per square foot, United States Government Standard:

Gauge	28	26	24	22	20	18	16
Weight in pounds	0.78	0.91	1.16	1.41	1.66	2.16	2.66

The following table is reprinted from the author's treatise on Furnace Heating:

TABLE I. — WEIGHT OF GALVANIZED IRON PIPE, THE AREAS AND CIRCUMFERENCES OF CIRCLES

Diameter Pipe Inches	Approx. Area Sq. inches.	Circumference Inches	Weight of Pipe per Running Foot						
			No. 28 Gauge	No. 26 Gauge	No. 24 Gauge	No. 22 Gauge	No. 20 Gauge	No. 18 Gauge	No. 16 Gauge
1	0.7854	3.14	—	—	—	—	—	—	—
2	3.1416	6.28	—	—	—	—	—	—	—
3	7.07	9.42	0.7	—	—	—	—	—	—
4	12.57	12.56	1.1	—	—	—	—	—	—
5	19.64	15.70	**1.2**	1.4	1.8	—	—	—	—
6	28.27	18.84	**1.4**	1.7	2.1	—	—	—	—
7	38.49	22.00	**1.7**	2.0	2.5	The heavy faced figures indi-			
8	50.27	25.13	**1.9**	2.2	2.8	cate the weight of pipes com-			
9	63.62	28.27	2.1	**2.4**	3.1	monly built of the gauge			
10	78.54	31.41	2.3	**2.7**	3.4	stated at the head of the			
11	95.03	34.55	—	**2.9**	3.7	column in which they occur.			
12	113.10	37.70	—	**3.2**	**4.1**	—	—	—	—
13	132.73	40.84	—	**3.4**	**4.4**	—	—	—	—
14	153.94	44.00	—	**3.7**	**4.7**	—	—	—	—
15	176.72	47.12	—	—	**5.0**	6.1	—	—	—
16	201.06	50.28	—	—	**5.4**	6.5	—	—	—
17	226.98	53.41	—	—	**5.7**	6.9	—	—	—
18	254.47	55.54	—	—	**6.0**	7.3	—	—	—
19	283.53	59.69	—	—	**6.3**	7.7	—	—	—
20	314.16	62.83	—	—	**6.8**	**8.2**	—	—	—
22	380.13	69.11	—	—	**7.3**	**8.9**	—	—	—
24	452.39	75.39	—	—	**8.0**	**9.7**	11.5	—	—
26	530.93	81.68	—	—	**8.7**	**10.6**	12.4	—	—
28	615.75	87.96	—	—	**9.4**	**11.4**	13.4	—	—
30	706.86	94.24	—	—	**10.0**	**12.2**	14.4	18.7	—
32	804.25	100.53	—	—	—	**13.0**	**15.2**	20.0	—
34	097.92	106.81	—	—	—	**13.9**	**16.3**	21.2	—
36	1017.88	113.00	—	—	—	**14.6**	**17.2**	22.4	—
38	1134.12	119.38	—	—	—	**15.5**	**18.2**	23.7	—
40	1256.64	125.66	—	—	—	**16.2**	**19.1**	**24.9**	30.7
42	1385.45	131.94	—	—	—	—	**20.1**	**26.1**	32.2
44	1520.53	138.23	—	—	—	—	**21.0**	**27.4**	33.7
46	1661.91	144.51	—	—	—	—	**22.0**		35.2
48	1809.56	150.79	—	—	—	—	**22.9**	**29.8**	36.7
50	1963.50	157.08	—	—	—	—	**23.9**	**31.0**	38.2
52	2123.72	163.36	—	—	—	—	—	**32.2**	39.7
54	2290.23	169.24	The diameter squared × 0.7854					**33.6**	41.4
56	2463.01	175.93	= area of a circle.					**34.9**	43.0
58	2642.09	182.21	The diameter × 3.1416 = cir-					**36.1**	44.5
60	2827.74	188.49	cumference of a circle.					**37.4**	46.0

Weights and Thicknesses of American Tin Plates

It is of interest to compare the weights of galvanized sheets stated in Table 1 with those of tin plates given in Table II, which is reprinted from the *Metal Worker* of August 25, 1900.

In regard to rectangular pipe, custom varies considerably in the gauges used; if properly stiffened lighter gauges may be used than for round pipes of the same area.

The following is taken from a United States Government specification: Rectangular ducts not exceeding 40 in. in width are to be made of No. 24 gauge; those wider than 40 in. to be made of No. 20 gauge. All surfaces of ducts 24 to 39 in. wide are to have V-shaped stiffening ribs, riveted in place outside of the ducts, spaced not over 30 in. apart. All ducts having a surface of 40 in. or over in width or depth must have $1 \times 1 \times \frac{3}{16}$-in. angle iron frames around them riveted to the ducts and spaced not over 30 in. apart. The ends of the various sections of ducts are to be finished with

Table II. — Weights and Thicknesses of Tin Plates

Denomination Pounds	Weight per Box of 112 Sheets, 14 x 20 Inches. Pounds	Approximate Weight per Square Foot in Decimals of Pound	Thickness in Decimals of an Inch
55	55	0.252	0.00625
60	60	0.275	0.00638
65	65	0.3	0.0075
70	70	0.321	0.008
75	75	0.344	0.0086
80	80	0.367	0.0092
85	85	0.39	0.0098
90	90	0.42	0.0105
95	95	0.436	0.0109
100	100	0.46	0.0115
IC	108	0.5	0.0125
Ix	136	0.625	0.0156
IXX	156	0.71	0.0178
IXXX	176	0.8	0.02
IXXXX	196	0.9	0.0225
IXXXXX	216	1	0.025

$1\frac{1}{4} \times 1\frac{1}{4} \times \frac{1}{4}$-in. angles. All ducts must be practically airtight when finished.

A specification for one of the largest department stores in the country states: Galvanized iron ducts 4 ft. square and greater are to be made of No. 22 gauge, smaller ones of 24 gauge. All joints are to be riveted airtight. All stiffening frames are to be of angle iron, painted. No wood construction allowed. Ducts must be thoroughly stiffened with 1-in. angle irons spaced not more than 4 ft. apart.

Estimating the Weights of Rectangular Piping

The accompanying table, compiled by W. G. Holmes, reprinted from the *Metal Worker* of July 8, 1899, is of great value for quickly figuring weights of rectangular piping.

The weight of elbows can be estimated quickly by computing the weight of a length of straight pipe equal to that of the center line of the elbow.

The weight is given in pounds per running foot, and the table covers all sizes from 2 × 2 in. to 60 × 60 in. The outer lines of figures are dimension figures; all other figures denote weights in pounds. It is obvious that all pipes having the same circumference must be of the same weight, provided, of course, that they are made of the same gauge of metal. Therefore, to avoid a repetition of figures diagonal lines are drawn across the sheet, each line representing a certain weight, which weight is indicated at each end of the line at intervals throughout its length.

To find the weight of a rectangular galvanized iron pipe of any size, find one dimension in inches in one of the horizontal (top or bottom) lines of figures, and the other dimension in one of the vertical side lines of figures; at the intersection of the columns headed by these figures will be found either a figure denoting the weight in pounds per running foot of a diagonal line which, when followed, terminates in a figure denoting the weight. For example, let it be required to find the weight per foot of a pipe 16 × 24 in. Find in the upper line the figure 16 and in the side line the figure 24, follow the columns and the space at their intersection is found to be

crossed by a heavy diagonal line; follow this line in either direction and the figure 12.9 is found, which denotes the weight in pounds per running foot.

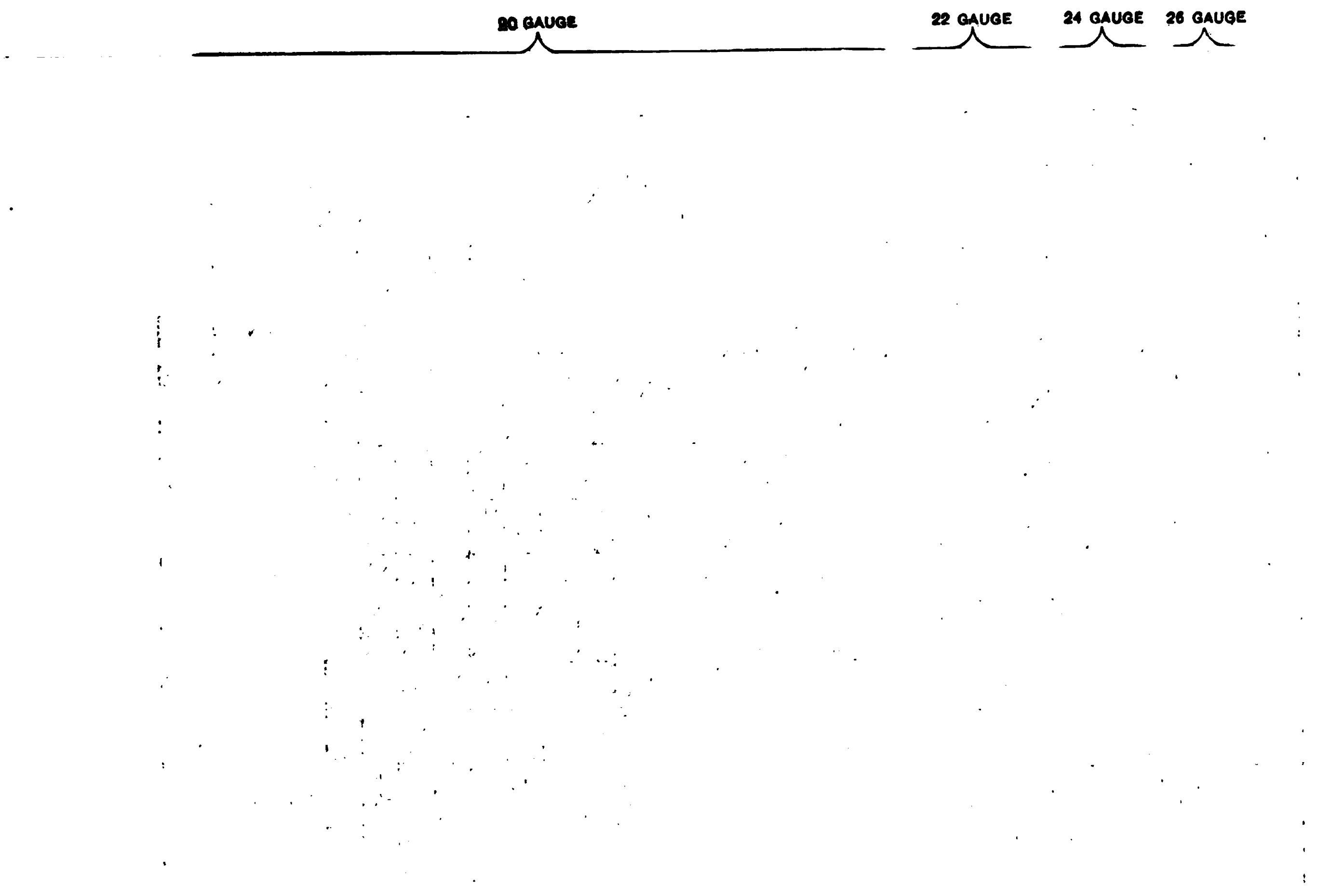
The diagonal lines are made alternately heavy and light to aid the eye in following them. This table has been in use for the last five years by one of the larger blower companies, and has been found in practice to agree closely with the weight of metal used in actual installations.

The following gauges are represented: From 2 × 2 in. to 6 × 6 in., No. 26; from 7 × 7 in. to 12 × 12 in., No. 24; from 13 × 13 in. to 20 × 20 in., No. 22; all above 20 × 20 in. No. 20. This represents about the average of the gauges used for fan work, the larger sizes requiring internal bracing. An allowance has been made for seams, laps, sleeves, rivets and solder, and waste when pipes are made from sheets 30 × 96 in. These weights may be readily converted into other gauges by using the usual factors.

Dampers, Deflectors and Hangers

Dampers for controlling the flow of air should be placed in all branch pipes and connections, for in all heating and ventilating work it is impossible to foresee all conditions that may arise in erecting a piping system. Adjustable dampers must be used to secure the desired distribution.

Fig. 198 shows an approved form of adjustable damper and fittings which can be used on round or rectangular ducts. Damper braces are made of cast iron and holes for riveting to the damper and for the damper rod are cored in the casting. The top of the brace is tapped out to receive a set screw for setting down on the damper rod. Screw castings are cast with a hole for the damper rod and holes for riveting to the ducts are cored in the casting, and the hole is tapped out to receive a set screw for adjusting the damper. The damper rod is made from stock wrought rod and generally made $\frac{3}{8}$ in. in diameter for small dampers and about $\frac{1}{2}$ in. for large dampers. Damper braces are also made in two sizes, for large and small dampers.


20 GAUGE
22 GAUGE
24 GAUGE
26 GAUGE

crossed by a heavy diagonal line; follow this line in either direction and the figure 12.9 is found, which denotes the weight in pounds per running foot.

The diagonal lines are made alternately heavy and light to aid the eye in following them. This table has been in use for the last five years by one of the larger blower companies, and has been found in practice to agree closely with the weight of metal used in actual installations.

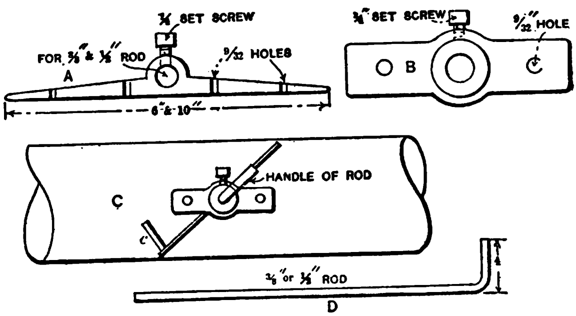
The following gauges are represented: From 2×2 in. to 6×6 in., No. 26; from 7×7 in. to 12×12 in., No. 24; from 13×13 in. to 20×20 in., No. 22; all above 20×20 in. No. 20. This represents about the average of the gauges used for fan work, the larger sizes requiring internal bracing. An allowance has been made for seams, laps, sleeves, rivets and solder, and waste when pipes are made from sheets 30×96 in. These weights may be readily converted into other gauges by using the usual factors.

Dampers, Deflectors and Hangers

Dampers for controlling the flow of air should be placed in all branch pipes and connections, for in all heating and ventilating work it is impossible to foresee all conditions that may arise in erecting a piping system. Adjustable dampers must be used to secure the desired distribution.

Fig. 198 shows an approved form of adjustable damper and fittings which can be used on round or rectangular ducts. Damper braces are made of cast iron and holes for riveting to the damper and for the damper rod are cored in the casting. The top of the brace is tapped out to receive a set screw for setting down on the damper rod. Screw castings are cast with a hole for the damper rod and holes for riveting to the ducts are cored in the casting, and the hole is tapped out to receive a set screw for adjusting the damper. The damper rod is made from stock wrought rod and generally made $\frac{3}{8}$ in. in diameter for small dampers and about $\frac{1}{2}$ in. for large dampers. Damper braces are also made in two sizes, for large and small dampers.

20 GAUGE 22 GAUGE 24 GAUGE 26 GAUGE



A BRACE FOR LARGE DAMPER
B " " SMALL "
C DAMPER_IN ROUND PIPE
c STOP TO PREVENT DAMPER CLOSING OTHER WAY
D DAMPER ROD

Fig. 198. — Type of Damper

Deflecting dampers are commonly used in ducts, at branches. These are commonly called switch dampers and the type is illustrated in Fig. 199

In factory buildings of slow burning construction hangers can be made up as shown in Fig. 200 when the ducts run at right angles to the floor beams. Where piping runs parallel to the floor beams a straight hanger of bar iron can be used by bending about 4 in. of the bar at right angles and fastening to the tongued and grooved flooring by at least two lag screws. This type is shown in Fig. 201.

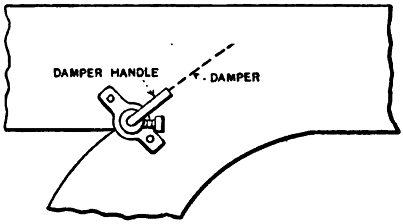


FIG. 199. — Type of Damper for Air Ducts

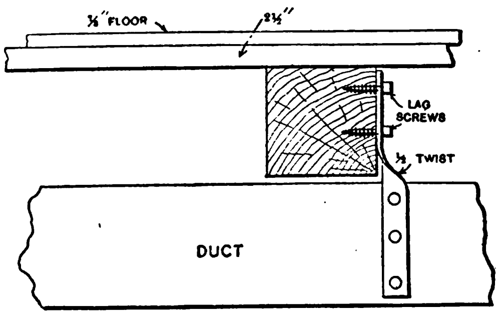


FIG. 200

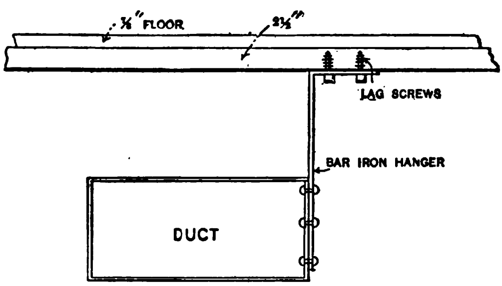


FIG. 201

Types of Hangers for Air Ducts

In buildings of fireproof construction, when the piping runs at right angles to the floor beams a hanger of the type shown in Fig. 202 may be used to good advantage. One-half of the beam clamp can be made as part of the hanger and the remaining half of the clamp made up and bolted fast.

Fig. 203 shows one method of hanging ducts from a concrete floor. The vertical irons riveted to the sides of the ducts are turned at right angles at the top and are drilled to receive the bolts passing down through the floor.

Fig. 204 shows a method of arranging the galvanized iron casing, the top being sheathed with wood against the floor timber and covered with tin or light galvanized iron.

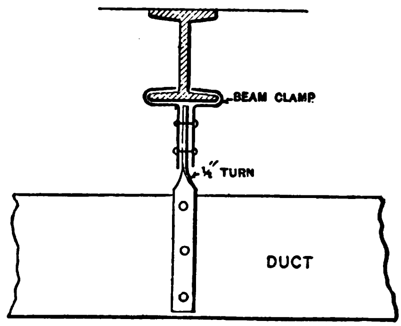


FIG. 202

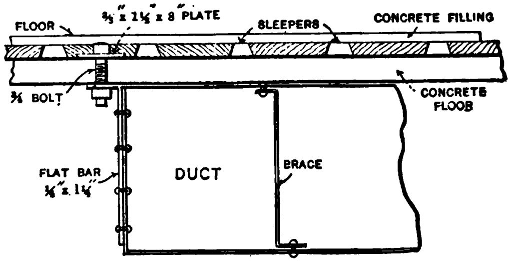


FIG. 203

Types of Hangers for Air Ducts

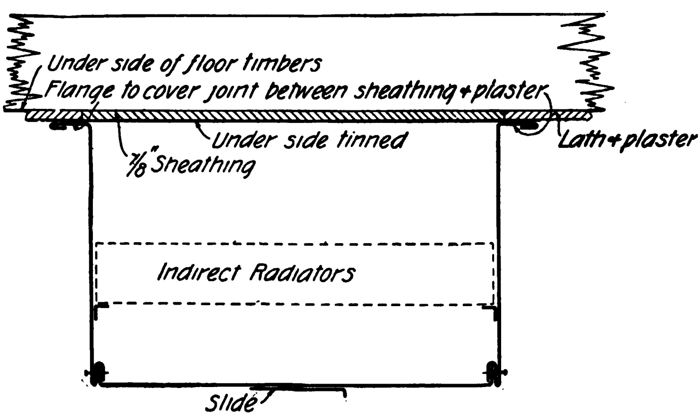


FIG. 204. — Details of Construction of Radiator Casings

One method of joining the corners is shown in Fig. 205. For deep casings the sides are made up of two sections joined by slip pieces as indicated in Fig. 206. The corners may be joined as shown in Figs. 207, 208 or 209. The bottom may be held in place as shown in Fig. 210, which can be attached more conveniently than as arranged in Fig. 204.

Govt clip

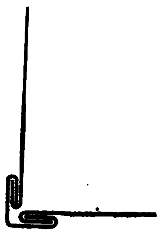


FIG. 205

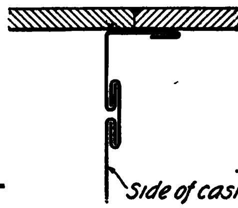


FIG. 206

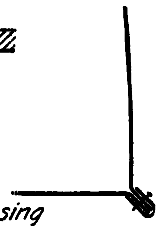


FIG. 207

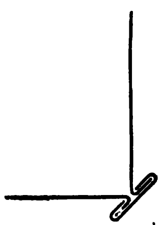


FIG. 208

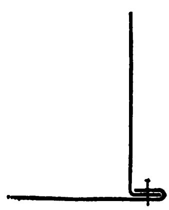


FIG. 209

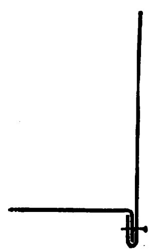


FIG. 210

Details of Construction of Radiator Casings

It is important in indirect work that galvanized iron stops be provided between the radiator and the casing to prevent any of the cold air "by-passing" the heating surface. It is well to place a small slide door in the bottom of the casing. As to hangers, several types are shown in Figs. 211, 212 and 213. Fig. 214 shows a casing provided with non-conducting material above.

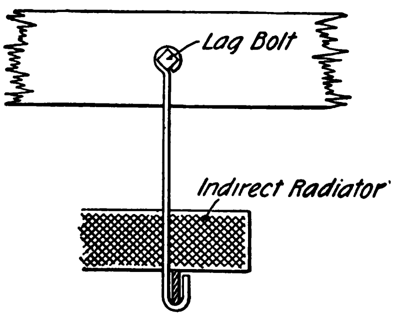


Fig. 211

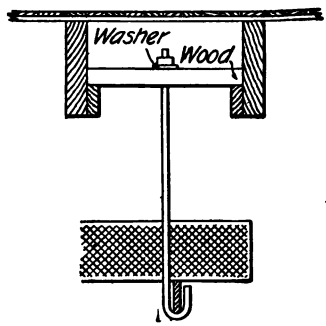


Fig. 212

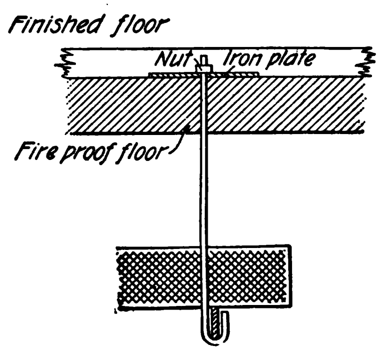


Fig. 213

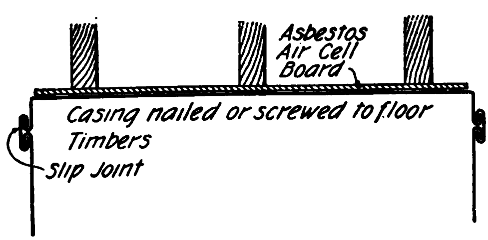


Fig. 214

Details of Construction of Radiator Casings

Obviating Noises in Fan Systems

Stopping noise from being carried through galvanized iron ducts from a fan can be accomplished so far as the transmission of vibration is concerned, by means of the canvas connection illustrated in the cuts. Fig. 215 shows the construction of the flexible joint for a circular pipe. The ends are located 4 to 6 in. apart and connected by the canvas sleeve which is slipped over the bead on the pipe, doubled under at the ends and secured in place by annealed galvanized wire drawn up tight.

For rectangular pipes the method shown in Figs. 216 and 217 may be used. The canvas is doubled under as before and held in place by stove bolts passing through the angle iron, canvas, galvanized iron and the strap iron inside the duct. The holes should be punched about 4 in. on centers, and before putting the strap iron in place in the inside of the duct, it should be placed on supports the same distance on centers as the holes and slightly bent as in Fig. 217, so that when drawn up in place by the bolts, the spring in the iron will force the galvanized iron hard against the canvas between it and the angle iron, making a tight joint. Canvas joints of this description should be thoroughly painted after they are put in place to prevent the leakage of air.

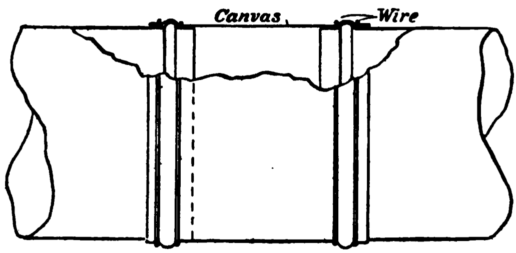


FIG. 215. — Flexible Joint for Round Pipe

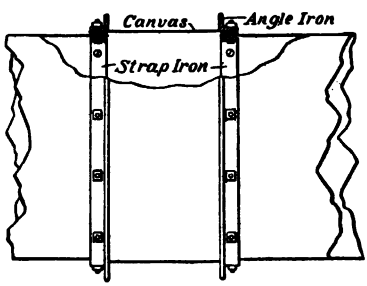


FIG. 216

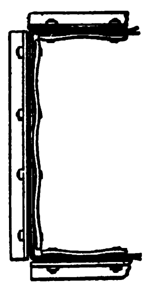


FIG. 217

Joint for Rectangular Pipe

CHAPTER VI

Reprints of Portions of Miscellaneous Articles Relating to Piping

Rules relating to boiler connections, etc., extracts from the Rules formulated by the Board of Boiler Rules of Mass., 1909.

Safety valve connections

1. Each safety valve shall have full-sized direct connection to the boiler, and when an escape pipe is used it shall be full-sized and fitted with an open drain, to prevent water lodging in the upper part of safety valve or escape pipe. When a boiler is fitted with two (2) safety valves on one (1) connection, this connection to the boiler shall have a cross-sectional area equal to or greater than the combined area of the two (2) safety valves. No valve of any description shall be placed between the safety valve and the boiler, nor on the escape pipe between the safety valve and the atmosphere. When an elbow is placed on a safety valve escape pipe it shall be located close to the safety valve outlet, or the escape pipe shall be securely anchored and supported.

Steam gauge

2. Each boiler shall have a steam gauge connected to the steam space of the boiler by a syphon, or equivalent device, sufficiently large to fill the gauge tube with water, and in such manner that the steam gauge cannot be shut off from the boiler except by a cock with T or lever handle, which shall be placed on the pipe near the steam gauge.

Feed pipe

3. Each boiler shall have a feed pipe fitted with a check valve, and also a stop valve or stop cock between the check valve and the boiler, the feed water to discharge below the lowest safe water line. Means must be provided for feeding a boiler with water against the maximum pressure allowed on the boiler.

Stop valve

4. Each steam outlet from a boiler (except safety valve connections) shall be fitted with a stop valve.

5. When a stop valve is so located that water can accumulate, ample drains shall be provided.

Valves on return pipes

6. The main return pipe to a heating boiler (Gravity Return System) shall have a check valve, and also a stop valve between the check valve and the boiler.

7. When there are two connected boilers (Gravity Return System), one (1) check valve *may* be placed on the main return pipe and a stop valve on the branch pipe to each boiler.

Stop valves

8. Each steam outlet from a boiler which is over two (2) inches in diameter (except a safety valve connection) shall be fitted with a stop valve or valves of the outside screw and yoke type, located as near the boiler as practicable.

9.. The stop valve or valves on the main steam pipe of a boiler shall be extra heavy when the pressure allowed exceeds one hundred and thirty-five (135) pounds. The fittings from boiler up to the valves shall be extra heavy, made to the manufacturers' standard for high pressures.

10. Two stop valves of the outside screw and yoke type, with an ample valved drain between them, having an open discharge, shall be placed on the main steam pipe of a boiler having a manhole, and set in battery, when the pressure allowed on any boiler in the battery exceeds one hundred and thirty-five (135) pounds.

Pipe threads

11. The minimum number of threads that a pipe or nipple shall screw into a fitting is given in the following table: —

Size of pipe connection, inches	1 and 1¼	1½ and 2	2½ to 4	4½ to 6	7 and 8	9 and 10	12
Number of threads per inch	11½	11½	8	8	8	8	8
Minimum number of threads into fitting	4	5	7	8	10	12	13

Valves on feed piping

12. When boilers of fifty (50) horse power or over are set in battery, each boiler shall have two (2) stop valves, or a stop valve and stop cock, on the feed pipe, one (1) on each side of the check valve.

Feed-water appliances

13. When a pump, inspirator or injector is required to supply feed water to a boiler of over fifty (50) horse power, more than one such mechanical appliance shall be provided.

Surface blow-off

14. The maximum size of a surface blow-off pipe shall not exceed one and one-half ($1\frac{1}{2}$) inches, and it shall be carried through the shell or head with a brass or steel boiler bushing, or the opening re-enforced.

Bottom blow-off and fittings

15. Each boiler shall have a bottom blow-off pipe, fitted with a valve or cock, in direct connection with the lowest water space practicable; the minimum size of pipe and fittings shall be one (1) inch and the maximum size shall be two and one-half ($2\frac{1}{2}$) inches. Globe valves shall not be used.

16. A bottom blow-off cock shall have the plug held in place by a guard or gland. The end of the plug shall be distinctly marked in line with its passage.

17. When the pressure allowed on a boiler exceeds twenty-five (25) pounds per square inch, the bottom blow-off pipe and fittings, from the boiler to the valve or valves, shall be extra heavy.

18. When the pressure allowed on a boiler exceeds one hundred and thirty-five (135) pounds per square inch, the bottom blow-off pipe shall have two (2) valves, or a valve and a cock; and such valves, or valve and cock, shall be extra heavy.

19. A bottom blow-off pipe shall be protected from the products of combustion by a fire-brick casing, substantial cast-iron removable sleeve, or covering of non-conducting material.

20. An opening in brickwork for a blow-off pipe shall be fitted with an ample cast or wrought iron sleeve, to provide for free expansion and contraction.

Water column pipes

21. The minimum size of pipes connecting the water column of a boiler shall be one (1) inch.

22. The water connection to the water column of a boiler shall be of brass when the allowable pressure exceeds twenty-five (25) pounds per square inch.

23. The steam connection to the water column of a horizontal return tubular boiler shall be taken from the top of shell or the upper part of head; the water connection shall be taken from a point not less than six (6) inches below the center line of the shell.

24. No connections, except for damper regulator, feed-water regulator, drains or steam gauges, shall be placed on the pipes connecting a water column to a boiler.

25. When shut-off valves are placed on the pipes connecting a water column to a boiler, these valves shall be of the straight-

way outside screw and yoke type, and shall be locked or sealed *open.*

26. No water glass connection shall be fitted with an automatic shut-off valve.

Steam mains

27. Provision shall be made for the expansion and contraction of steam mains connected to all boilers, with substantial anchorage at suitable points, that there may be no perceptible vibration on the boiler shell plates.

28. Steam reservoirs shall be used on steam mains when heavy pulsations of the steam currents cause vibration on the boiler shell plates.

Steam Piping for Industrial Plants

Extracts from an article by W. E. Housman, in *Engineering Magazine.*

Every steam line should start with a valve placed at or very near the connection to the steam boiler, and the grade from this point on should be with the current of steam. With a stiff up grade against the flow, water will collect at the foot of the grade until a slug is formed. Finally it will be picked up and, traveling at high velocity, may wreck the first cast fitting encountered. Therefore, at the foot of every vertical rise and change of grade, a drip pocket or water leg should be placed, into which the greater part of the water will fall, to be removed by a steam trap. Too much attention cannot be given to this question of drainage. The quantity of water in the steam is variable even in the best covered lines. It will increase as the boilers are forced, or a sudden or excessive demand on the line may lift water out of the boiler. . . .

A receiver-separator is very useful at the end of a long line. It not only takes care of large bodies of water, storing them until the trap can expel the water, but it will maintain an even flow of steam regardless of sudden demands made by the steam users. Its use will often permit a smaller line to be used for a predetermined drop in terminal pressure. With high-speed automatic engines, receiver-separators are especially valuable; they insure a steady flow of steam in one direction only and serve as a cushion to receive the hammer or vibration due to the quick action of the steam valve. . . .

All pipe considered in this article is what is known as "wrought-iron." This has now become a general term which includes all butt or lap-welded pipe of either steel or iron. When material is not

distinctly specified, the pipe received will usually be steel, and will be under-weight by from 5 to 10 per cent, the greater variation being on piping from 8 to 12-inch, inclusive; "full-weight" pipe will run very close to the list weight and should be specified on all live-steam work. For bends of radius less than six diameters, extra strong pipe is often advisable to compensate for the stretch on the outer curve of the bend. Piping larger than 12-inch is listed by external diameter and is called "O. D. pipe." The thickness of metal must be specified in ordering — usually $\frac{3}{8}$-inch for live-steam in sizes 14 to 18 inches, inclusive. O. D. pipe lighter than $\frac{5}{16}$-inch cannot be threaded.

The best three methods of attaching flanges to wrought pipe, all reliable to 200-pounds pressure, will be mentioned in the order of their cost: When properly made, the screw joint gives perfect results with the minimum cost. . . . To make a good screw joint requires only that the flange be tapped true, the threads on the pipe cut to a long true taper, and the relation between male and female such that the pipe can be screwed home to the shoulder without heating. Any grit or dirt on the threads will produce added friction and consequent heat, hence the threads must be made clean before applying the graphite or other lubricant used to reduce friction. It must be understood that when a joint becomes hot, it will afterwards leak; the lighter tube will expand more than the flange, while making the joint, and on cooling, will shrink more than the flange. If the thread is of proper length, the end of the pipe will project through the flange. This portion is faced off, at the same time taking a light cut over the face of the flange. In long steam lines, only sufficient flange couplings are needed to facilitate a repair or alteration, the intermediate connections being the standard forged sleeves or couplings. . . .

The lap joint, formed by machine-swaging the end of the pipe over the face of the flange, is absolutely safe and has an advantage in that the flanges, being loose on the pipe, may be turned to match the holes in the fittings. Its cost is about one and one-quarter times that of a screw joint and steel flange. It follows that every joint must be flanged.

The welded joint is made by machine-welding a forged-steel flange to the pipe. Its cost is about one and three-quarters that of a screw joint and steel flange.

Flanges, for live steam, should be of rolled or cast-steel, especially on expansion bends. It is the pipe flange which will fail, almost never the flange on a valve or fitting. They should be rough-faced for thin copper or rubber gaskets. For the pressures here considered, tongued-and-grooved flanges are not necessary and their use makes it difficult to remove a section of pipe or a fitting.

Boiler Valves

Notes from an article on Boiler Headers and Connections by H. J. Ott, in *Power and the Engineer*, Aug. 11, 1908.

Many cities by ordinance now require two valves in each connection, and many engineers know only too well what it means to crawl into a boiler with a leaky valve on top of them. This condition can be eliminated by the use of two valves. One of the neatest and most efficient arrangements is to use two angle valves, one on top of the header and the other on top of the boiler. . . .

Automatic stop and check valves are daily finding favor and are coming into general use. These valves, which are adaptations of the ordinary check valve, are generally made in the angle type to set over the boiler outlet. The disc falls to its seat when the flow of steam reverses, so that if a tube should blow out the automatic stop and check or non-return valve would close because of the unbalanced pressure, thereby isolating the disabled boiler from the others. The advantages of such an arrangement are fully apparent. The check disc in these valves is not attached to the valve-stem, but the valve can be used as an ordinary stop valve by screwing the stem down until it holds the disc securely on its seat. It is impossible to open this type of valve when the boiler is out of commission, and this in itself is a safety item to be considered by those who have to enter boilers for cleaning or repairs. The non-return valve will also close if the boiler becomes sluggish in generating steam and will not open until the pressure equals that in the header. The valve should be equipped with an outside lever or indicating device which will clearly show whether it is open or closed.

There are a few types of non-return valves which have an added feature of closing if the velocity should increase in the regular direction beyond the normal rate, which might easily be caused by the bursting of a pipe or joint in the piping system. The location of

the automatic stop and check valves should be as near as possible to the boiler outlets. Where the ordinary angle or gate valves are used, they should preferably have rising stems to readily indicate whether the valve is open or closed.

The Use of Automatic Stop-Valves in Connection with High-Pressure Piping

Extracts from an article on The Protection of Steam Pipes from Accident, by Arthur Herschmann, in the *Engineering Magazine*, Dec., 1907.

Watt's low-pressure engine was invented in 1768.

In the year 1801 Evans invented the high-pressure engine. The compound engine followed about 1850, the triple-expansion engine in 1880, and about 1890 the steam turbine became popularly known. Simultaneously, steam pressures have been constantly increased so as to obtain increased economy of coal consumption, and we find that today pressures of 150 pounds per square inch are in common use and that locomotive and marine boilers are operated at 250 to 300 pounds. The superheating of steam has also been known for a great many years as a means of obtaining increased economy.

The danger of a failing steam pipe, or of other damage in the steam line permitting the sudden escape of steam, naturally is greatest with the highest pressure. The heat energy liberated to work damage is represented not only by the steam itself, but even more particularly by the heated water contained in the boiler which passes into sudden evaporation as soon as the pressure is suddenly taken off its surface. . . .

Even in the best designed boiler room little opportunity exists to reach the exits safely should a large pipe burst and permit the boilers to empty their contents. . . .

In view of this terrible danger many provisions are made to render pipes safe. The design of the piping is studied with the greatest care, so as to avoid initial strain. Special care is taken to provide for expansion, loops being frequently resorted to, and pitch is given so as to facilitate the flow of condensation. To minimize the possibility of rupture, piping of this class has even been strengthened by steel and copper wire winding. All these devices tend to reduce the chances of a pipe failure; but as experience proves that the failure cannot be rendered an impossibility, means must be provided

to check the rush of steam and isolate the defective line in case of the break of a pipe or fitting.

For the last fifty years valves have been on the market which could be operated mechanically from a distance, using levers, gears and chains, and more recently these devices have been designed to be actuated electrically. It is, however, plain that such a device will be a partial protection, at best. . . .

In the pipes of the average power plant, steam travels at the rate of a mile per minute, or about that — say 90 feet per second for maximum average speed. Should a pipe break, the velocity of outflow will be 900 feet per second, in round figures. . . .

In the United States this subject has in the last few years been given considerable attention and there are probably not many experienced engineers who do not recommend pipe protection. In France automatic valves have been compulsory since 1886. . . .

Whether the installation of such safeguard devices proves demonstrably profitable or not, the investment represented by them should be made out of the profit and loss account. . . .

That pipe protection saves life is no longer questioned by those in a position to know of the occurring pipe failures, although these may not be reported in the daily press. To such persons it is a matter of surprise to notice that occasionally the question is still raised if it is not a safe gamble just "to depend on the piping." The tendency of the times is to be more and more exacting that every known precaution shall be taken to protect life and limb.

VALVES

From an article on Steam Pipe Work, by W. S. HUYETTE, *Heat. and Vent.* Mar. 15, 1897.

It always pays to buy the best valves, for every pound of hot water or steam lost means the loss of the coal used to heat it and coal means money — many times the only thing that the owner will notice. The kind of valve depends upon the purpose for which it is to be used. For stop valves requiring no throttling adjustment between full open and tight shut, gate valves are probably the most popular, as they give a full opening of the pipe and consequently the pipes are perfectly drained.

If double disc valves are used care should be taken to see that the

valve stems stand vertically, so that the discs tend to drop into place, for if they are connected in horizontal position, or stem turned downwards, the discs tend to fall out of place. A good solid disc wedge gate valve can be used in any position with equal results. In the large size gate valves it is very desirable to have a plugged hole in the bottom of the space between the discs for blowing out dirt and pipe cuttings.

If the valve is to be used as a throttle valve, then use nothing but a globe valve. The preferable form of globe valve depends upon the use for which it is intended. If it is to be used often it is desirable to have a removable flat disc, so that in case of leaking the valve can be made perfect for a few cents for a new disc. If the valve is to be used as a stop valve and is not intended to be used several times a day, then a bevel metal-seated valve will be satisfactory.

Globe valves should always be connected so as to close against the pressure, so that in case the nut which secures the disc should work off, as sometimes happens, the steam pressure would open the valve. Then, in case of the disc coming loose or falling off, the run could at least be finished before making repairs. Also, in case the nut is only part way off, there is no danger of having the disc suddenly pulled off its seat and admitting steam with a sudden rush.

If globe valves are placed in horizontal pipes, always insist in having the stem stand horizontally, as in this position, and in no other, will the pipe drain properly. If the valve is set so that the stem is vertical, then the walls forming the valve seat make a dam which will hold the water in the pipe until it is about half full.

The Abuse of Valves

From the *Valve World*, May, 1906.

The following are a number of reasons why valves leak after being placed in a pipe line: —

1. We are confident that ninety per cent of all the trouble with leaky valves arises from the improper use of cement, and from the failure to remove the particles of cement, scale, chips, dirt, etc., that naturally get into the pipe while it is lying around a building and then lodge on the valve seat after steam is turned on.

When applying cement, it should be put on the male part only, for if placed on the female part, it goes through the pipe and gets on

the valve seat. In any case much more cement is used than is really necessary.

If steamfitters would take pains to apply the cement as above directed, and also make sure the pipe is clean by standing it on end and striking it a few times with a hammer, before putting it into place, in order to loosen any scale or dirt that may be inside, an immense amount of trouble would be avoided.

As a further precaution, it is well, when a job is started up, to open all the valves throughout the building and blow the steam through them thoroughly. After doing this properly there will be very little material in the pipes to cause trouble. After the job has been run a short time, it would be well, as an additional precaution, to clean out all the valves thoroughly.

2. It occasionally happens that threads on pipe are cut longer or smaller than standard, in which case, if the pipe is screwed into the valve, it very likely will run up against the partition and injure it.

3. In the lighter class of valves, one of the common abuses is the application of a pipe wrench on the opposite end of the valve from the end which is being screwed on the pipe. This should never be done, as it invariably springs the valve and of course causes it to leak.

4. If a light valve is put into a vise for the purpose of removing the centerpiece, the valve should certainly be clamped lengthwise.

In all cases when removing centerpiece care should be taken to have the disc some distance from the seat, as otherwise the disc will be forced onto the seat and some part of the valve become strained.

Never use an old strained monkey-wrench on a centerpiece, as such wrench is quite likely to squeeze the corners of centerpiece out of shape.

If found impossible to remove the bonnet or centerpiece by ordinary methods, heat the body of the valve just outside the thread with a blowtorch, or any other available means that can be applied to the body and not to the centerpiece. Then tap lightly all around the thread with a soft hammer. This method never fails, as the heat expands the body and breaks the joint made by the litharge or cement.

5. Often when a stuffing-box leaks, a steamfitter will endeavor to stop the leak by straining the stuffing-box with a large wrench, when the difficulty is due to the packing having become worn out and needing to be renewed.

6. It sometimes happens that when a valve is to be used on a header, the steamfitter will start out with a long piece of pipe that is unsupported, and, through carelessness, will allow the strain of the pipe to come on the valve, thereby springing it.

7. Serious trouble is also likely to occur in a pipe line where light valves are used through the fitter not making proper allowance for expansion and contraction and allowing the strain to be thrown on the valves. The pipe and fittings are much more rigid and stiff than the lighter brass valves, and in consequence the expansion strains will relieve themselves at the weakest point, unless otherwise provided for.

8. Very often, when a valve leaks, some one will stupidly undertake to tighten it by using some kind of a lever on the wheel. This should never be done, as it will in all probability injure the valve. As the trouble undoubtedly is due to the presence of dirt in the valve, it is very much better in such cases to take the valve apart and clean the seat.

Notes on Wrought-Iron Pipe

Furnished by the Crane Company, Chicago, Ill.

Wrought-iron Pipe. — This term is now used indiscriminately for all butt- or lap-welded pipe, whether made of iron or steel.

Merchant Pipe. — This term is used to indicate the regular wrought pipe of the market, and such orders are usually filled by the shipment of soft steel pipe. The weight of merchant pipe will usually be found to be about five per cent less than card weight, in sizes $\frac{1}{8}$-inch to 6-inch, inclusive; and about ten per cent less than card weight, in sizes 7-inch to 12-inch inclusive.

Full-weight Pipe. — This term is used where pipe is required of about card weight. All such pipe is made from plates which are expected to produce pipe of card weight; and most of such pipe will run full card to a little above card; but owing to exigencies of manufacture, some lengths may be below card, but never more than five per cent.

Large O. D. Pipe. — A term used to designate all pipe larger than 12-inch. Pipe 12-inch and smaller is known by the normal internal diameter, but all larger sizes by their external (outside) diameter, so that "14-inch pipe," if $\frac{3}{8}$ inch thick, is $13\frac{1}{4}$ inch inside, and "20-inch pipe" of same thickness is $19\frac{1}{4}$ inch inside.

The terms "Merchants" or "Standard pipe" are not applicable to "Large O. D. Pipe," as these are made in various weights, and should properly be ordered by the thickness of the metal.

When ordering large pipe threaded, it must be remembered that $\frac{1}{4}$ inch metal is too light to thread, $\frac{5}{16}$ inch being the minimum thickness.

Orders for large outside diameter pipe, wherein the thickness of metal is not specified, are filled as follows:

Fourteen, fifteen and sixteen-inch, O. D., $\frac{5}{16}$ inch or $\frac{3}{8}$ inch metal. Larger sizes, $\frac{3}{8}$ inch metal.

This pipe is shipped with plain ends, unless definitely ordered "threaded."

Extra Strong Pipe. — This term designates a heavy pipe, from $\frac{1}{8}$-inch to 8-inch only, made of either puddled wrought iron or soft steel. Unless directed to the contrary, steel pipe is usually shipped. If wrought-iron pipe is required, use the term, "Strictly Wrought-iron Extra Strong Pipe." Extra strong pipe is always shipped with plain ends and without couplings, unless instructions are received to thread and couple, for which there is an extra charge.

This term, when applied to pipe larger than 8-inch, is somewhat indefinite, as 9-, 10-, and 12-inch are made both $\frac{7}{16}$ and $\frac{1}{2}$ inch thick. Pipes $\frac{1}{2}$ inch are carried in stock and furnished on open order.

Double Extra Strong Pipe. — This pipe is approximately twice as heavy as extra strong, and is made from $\frac{1}{2}$ to 8 inches in both iron and steel. It is difficult, however, to find any quantity in "Strictly Wrought-iron" and the stock carried is usually soft steel. This pipe is shipped with plain ends, without couplings, unless ordered to thread and couple, for which there is an extra charge.

Pipe Bends

From an article on Some High Pressure Steam Pipe Details, by James Acton Miller, *Cassier's Magazine*, 1906.

Fig. 218 (See page 264) illustrates the relative saving to be effected in passing around a corner with a line of piping. It will be seen that to use an elbow in a run of piping, and measuring, say, 10 feet each way in the line, taking 10-inch pipe to illustrate the case, will require about 18 feet of pipe and a long-radius, extra-heavy cast-iron elbow, two companion flanges, two gaskets, two sets of bolts, and the cutting

of two threads, and these, taken with the cost of making up the two joints, even figuring at close wholesale cost, will run up to about $30 in actual cash outlay. A thing, however, that is in such common use as the fittings of the present day, is often looked upon as not costing anything, or, in other words, the contractor or engineer

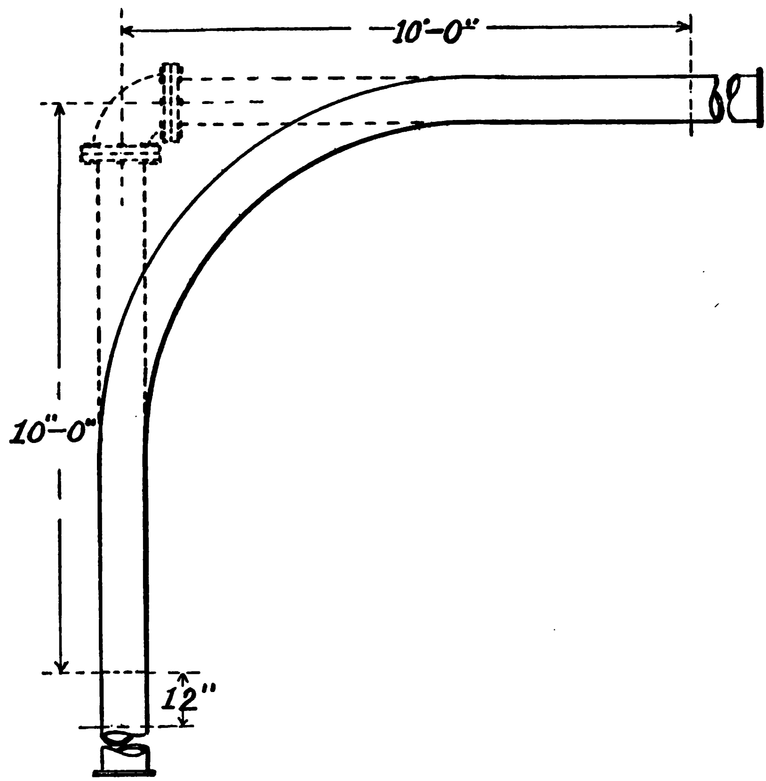


FIG. 218. — Saving by the use of a bend as compared with an elbow

does not figure the cost of a thing which is so easy to get as an ordinary elbow, but simply uses it on general principles, whereas if he stopped to count the cost, he would soon see that there was a cheaper way of doing this work, ignoring even the fact that it is better to do it with a wrought bend in any case, even if it cost double.

Counting, as above, 18 feet made into a bend of fair radius, or 8 times the diameter of the pipe, such a bend will reach around the

corner to be passed and go about 12 inches farther than the same length of pipe in using the expensive elbow. To bend the pipe itself should not cost one-third as much as the elbow; hence the saving with the bend will be fully two-thirds of the cost of the parts used with the elbow; about the same length of pipe is necessary in both cases.

From this it would seem that there is no saving in using ordinary fittings as applied in this class of work, but at the same time, after the job is up, the difference in cost has only commenced, as the friction in the passing of steam around the elbow, attended by condensation and wet steam, will cause a loss of many times the cost above referred to every year that it is used. . . .

As the demand for bends increases, they will cost less, and will ultimately be furnished, so far as the cost of the work is concerned, in standard sizes and radii at a cost of less than moulding and machining the present cast-iron elbow.

This statement, of course, has reference more especially to the larger size of piping, but even in hot water heating systems, sprinkler jobs, and small pipe work, frequent savings can be effected by the use of wrought bends instead of elbows, increasing the efficiency and circulation of the hot water or other system; and this is also true in conveying liquids generally.

On the other hand, with the lines of piping that are now up, and especially those in which the steam pressure has been increased, it is the judgment of the best engineering talent of the day that all elbows should be removed and well-made wrought bends substituted for them.

This reasoning is prompted by the additional fact that the old elbows are dangerous to all persons who work near them, as the expansion and contraction of the lines of piping on each side increases the strain beyond a reasonable factor of safety, and then it is only a matter of time when the fittings will break, with disastrous results to their surroundings.

Reports are frequent of bursting of lines of piping, with consequent property destruction and frequent loss of life. It will be found in nine cases out of ten where such accidents are reported that, in place of the pipe bursting, it has been the failure of an elbow or cast-iron flange, or something of that character on the pipe in place of the pipe itself. . . .

There are several features connected with pipe bends that are worth further consideration here. One of these is self-evident — that is, that the larger the radius to which the pipe is bent the farther it reaches in the line; or, in other words, the already-mentioned piece of wrought pipe, bent on a center radius of 80 inches, will go much farther around the corner to be passed than one bent on 40 inches.

Another lies in the fact that the larger radius is much easier to bend.

One point in connection with the making of wrought bends that was omitted in its proper connection above is that, in bending pipe, especially in larger sizes, it will nearly always show slight buckles on the inside of the bend; but in the opinion of the writer, it is better to have these left just as they come than to have the pipe bent in such a way as to stretch it unduly on the outside of the bend to obviate buckles. It is considered better practice to leave them without hammering them down, as steel pipe will not stand this usage very well. It is liable to cause slight fractures in the metal or produce a laminated condition, weakening it very materially.

If, in ordering bends, the above were mentioned so that the maker of the bends could leave the pipe without hammering, the user would get a much better and safer job, for the reasons above stated. Similarly, where it is possible to do so, the radius of the bends might well be left to the maker's judgment as to what the pipe will stand. If he is at all considerate of his own interests as well as those of his customer, he will make them of such character as will be best suited for the purpose, and, at the same time, at a price that will be a saving to the purchaser. Many other points of similar nature will probably occur to the reader in giving this matter attention.

Flanged Joints

From an article on Some High Pressure Pipe Details, by James Acton Miller, *Cassier's*, 1906.

There are many good reasons for doing away with screwed flanges, a few of which we will consider. Cutting threads is a very uncertain thing with steel pipe so largely used, as the threads will break and tear off and give trouble in many ways, making the weakest point in the entire line in the threads themselves. The average cast-iron flange is screwed on the taper thread so forcibly that the wedge action

of the thread will produce a strain on the flange, equaling, if not far exceeding, its safe limit of strength. When to this the steam pressure is added, pulling in the same direction, it is not remarkable that flanges break.

Another thing, it is about as expensive to cut threads, put on a flange and face it off, as it is to flange the pipe out, as shown in Fig. 219, and, if properly made, the latter leaves the pipe in good condition and will make a joint that will stand more pressure than the body of the pipe itself.

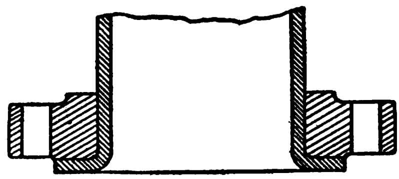


FIG. 219. — A good form for a flanged joint

This is not said in derogation of welded flanges; but the flanged-out portion of the pipe, reaching out to the bolt holes, gives just as much surface to carry packing as any flange does, and it is only a question of time when flanged-out joints and welded joints will be universal and will be furnished at less cost than the ordinary threaded pipe, so far as making completed joints are concerned.

FLANGED JOINTS FOR PIPES

Crane Co., in *Valve World*, March, 1906.

The screwed joint is by far the most popular manufactured by this company, its sales exceeding those of all the other styles combined. Many of the screwed joints on the market are manufactured in a very slipshod manner, and unsatisfactory experience with these poorly made joints has prejudiced some users against this type of joint. It has been our experience, however, that when properly made, screwed joints give very satisfactory service.

An objection sometimes advanced against screwed joints is that cutting the thread weakens the pipe. Practically, this objection does not hold good, for the reason that the flange into which the pipe is screwed always strengthens the part where the thread is cut. In many destructive tests made in the Crane works, pipe has always burst longitudinally at a point some distance from the thread, never giving way at the thread. We have no record of ever receiving a complaint of pipe giving way at the thread.

In the manufacture of the screwed joint, the flange is screwed on

by powerful machinery until the pipe projects through. The length of pipe is then placed in another machine and the end turned off flush with the face of the flange, a light cut being taken off the flange at the same time to insure its face being perfectly square with the pipe. One of the secrets of making a tight screwed joint is to have the threads perfectly clean. Great care must also be exercised in tapping and threading, in order that the pipe may be screwed up to the shoulder of the flange without the exposure of any part of the thread, which would result in a weak joint.

When screwed joints are used, the flanges should be made of metal of a much higher tensile strength and ductility than the flanges on the valves or fittings to which they are bolted. Cast-iron flanges are sometimes strained almost to the bursting point when they are screwed on the pipe, as very powerful machinery must be employed in the operation, to insure an absolutely tight joint. After erection, the additional strains due to expansion, contraction, internal pressure, drawing of bolts, etc., may cause the cast-iron flange to give way. In nearly all cases of failure of cast-iron flanges, both in destructive tests and actual experience, it is the flanges on the pipe that give way, not the flanges on the valves or fittings.

We make screwed joints in sizes from 1 to 24 inch, inclusive, with flanges of cast iron, ferrosteel, malleable iron, cast steel and weldless steel.

Following is a statement of the average tensile strengths in pounds per square inch of materials from which the flanges used on Crane joints are made: cast iron, 22,500; ferrosteel, 33,500; malleable iron, 37,000; cast steel, 55,000; weldless steel, 60,000.

The lap joint is free from the imaginary or real defects of the screwed joint, and is considerably more expensive.

In constructing the Crane lap joint, the face of the flange is beveled to the width of the lap. The difference in the thickness of the pipe between the inside and outside portions of the lap, due to drawing the pipe over, is compensated for, and in this manner the full thickness and strength of the pipe at the lapping-over point is retained.

The flanges on Crane lap joints are loose and swivel. This feature is of great advantage when it is necessary to change the position of bolt holes in the field, which can be done without extra expense or labor. Crane lap joints are supplied in sizes from 4 to 24 inch, inclusive.

The Relative Corrosion of Wrought Iron and Steel [1]

On one hand, we have the very general public opinion that steel corrodes not only faster but very much faster than wrought iron, an opinion held so widely and so strongly that it cannot be ignored. On the other hand, we have the results of direct experiments by a great many observers in different countries and under widely differing conditions, and these results certainly tend to show that this popular belief is completely wrong and that, on the whole, there is no very great difference between the corrosion of steel and wrought iron. Under certain sets of conditions steel seems to rust a little faster than wrought iron, and under others wrought iron seems to rust a little faster than steel. . . .

The fact that steel has come into wide use simultaneously with a great increase in the sulphurous acid in our city air and of strong electric currents in our city ground may well lead the practical man, be he hasty or cautious, into inferring that the rapid corrosion of today is certainly due to the new material of today, steel, whereas, in fact, it may be wholly due to the new conditions of today, sulphurous acid and electrolysis. . . .

Differences Between Iron and Steel

There are three prominent differences between iron and steel which ought to cause a difference in their rapidity of rusting: First, blowholes: second, manganese, and third, the presence of cementite in the steel and of cinder in the wrought iron. Let us take these up in order and see how they require that direct tests should be very prolonged or pushed to destruction:

1. Blowholes exist in steel, but not in wrought iron. But blowholes, at least blowholes which do not weld up and thus cease to exist, are not necessary. Yet they are to be prevented only by care and skill. Hence, get your steel only from careful and trustworthy makers.

2. Manganese steel always and almost necessarily contains more manganese than wrought iron. This may or may not hasten its

[1] A contribution by Henry M. Howe to the discussion on the "Corrosion of Iron and Steel," at the meeting of the American Society for Testing Materials, at Atlantic City, June 22, 1906.

rusting. If it does, then its effects ought to be made manifest even in short time tests. From the fact that such tests do not show that steel rusts materially faster than wrought iron, I infer that this manganese is probably not a serious cause of rusting.

3. Steel is generally richer than wrought iron in cementite, the iron carbide. Wrought iron always contains very much more cinder than does steel. Each of these substances, the cementite of the steel and the cinder of the wrought iron, may have a double influence on corrosion, hastening it through difference of potential and retarding it by acting as a mechanical barrier like so much paint, to exclude the oxygen or the air or the water. It is not clear that the influence of difference of potential ought to change materially as corrosion proceeds, but it is clear that mechanical protection given by the plates of cementite and of cinder ought to increase as corrosion proceeds. When a piece of wrought iron, for instance, is first exposed to corrosion, only the outcrops, so to speak, of the sheets of cinder come to the surface. Its mechanical protection is very small. But as corrosion proceeds, and more and more of the metal which at first overlay the sheets of cinder is eaten away, the remaining cinder forms a larger and larger proportion of the outer surface, and therefore protects a constantly increasing proportion of the underlying metal from corrosion. In short, the mechanical protection afforded by the cinder ought to increase as corrosion proceeds.

Here, then, is a cause which, as corrosion proceeds, should continuously tend to retard the corrosion of wrought iron, and to make it compare more and more favorably with steel. But, in like manner, as steel is gradually corroded away, more and more of its surface should come to be composed of cementite, and this fact should tend to retard the corrosion of steel, because cementite, too, should protect the underlying free iron or ferrite. . . .

Two other points: Sheet steel roofing may rust faster than iron because the latter holds the paint better, and yet steel in other forms, like tubing, may rust no faster than wrought iron. Again let me emphasize the difference between different steels. Carelessly made steel containing blowholes may rust faster than wrought iron, yet carefully made steel free from blowholes may rust more slowly. Recognize that any difference between the two may be due not to the inherent and intrinsic nature of the material, but to defects to which it is subject if carelessly made. Care in manu-

facture and special steps to lessen the tendency to rust might well make steel less corrodible than wrought iron, even if steel carelessly made should really prove more corrodible than wrought iron.

To Ascertain whether Pipe is made of Wrought Iron or Steel

Wrought Iron Pipe *vs.* Steel Pipe, from Reading Iron Co. Booklet, May, 1906.

Cut off a short piece of the pipe and suspend it in a solution of 9 parts of water, 3 parts of sulphuric acid, and 1 part of muriatic acid. First place the water in a porcelain or glass dish, adding the sulphuric and then the muriatic acid. Suspend the pipe in such a way that the end will not touch the bottom of the dish. After about two hours' immersion remove the pipe and wash off the acid. If the pipe is steel the end will present a bright, solid, unbroken surface, while if made of iron it will show faint ridges or rings, like the year rings in a tree, showing the different layers of iron and streaks of cinder. In order that the scratches made by the cutting-off tool may not be mistaken for the circular cinder marks, it is advisable to file the end of the pipe straight across or grind on an emery wheel until the marks of the cutting-off tool have disappeared before putting it in the acid. It sometimes happens that a bubble of gas or air has been caught in the interior of the steel ingot, which, after being rolled into skelp, will form a blister: *i.e.*, a seam which has not been welded together. But this can easily be distinguished from the circular cinder marks referred to above by being generally visible before the pipe is immersed in the acid. When such a blister occurs in iron pipe, the circular cinder marks will appear in addition to the ring mark made by the blister.

The fact that steel has a smoother surface than iron furnishes a very obvious reason why galvanizing should adhere better to iron than to steel, and all galvanizers using the hot metal process will certify to the fact that it requires more zinc to galvanize iron pipe than steel pipe. This materially increases the protection given to iron.

"THE 1912 U. S. STANDARD"
SCHEDULE OF STANDARD FLANGES

FOR STEAM PRESSURES UP TO 125 LBS. PER SQUARE INCH
ADOPTED BY THE NATIONAL ASSOCIATION OF MASTER STEAM AND HOT WATER FITTERS
THE AMERICAN SOCIETY OF MECHANICAL ENGINEERS, THE AMERICAN SOCIETY OF HEATING AND VENTILATING ENGINEERS

All dimensions are in inches

Size of Pipe	Diameter of Flange	Thickness of Flange	Diameter of Bolt Circle	Number of Bolts	Size of Bolts	Diameter of Bolt Holes
1	4	7/16	3	4	7/16	9/16
1¼	4½	½	3⅜	4	7/16	9/16
1½	5	9/16	3⅞	4	½	⅝
2	6	⅝	4¾	4	⅝	¾
2½	7	11/16	5½	4	⅝	¾
3	7½	¾	6	4	⅝	¾
3½	8½	13/16	7	4	⅝	¾
4	9	15/16	7½	8	⅝	¾
4½	9¼	15/16	7¾	8	¾	⅞
5	10	15/16	8½	8	¾	⅞
6	11	1	9½	8	¾	⅞
7	12½	1 1/16	10¾	8	¾	⅞
8	13½	1⅛	11¾	8	¾	⅞
9	15	1⅛	13¼	12	¾	⅞
10	16	1 3/16	14¼	12	⅞	1
12	19	1¼	17	12	⅞	1
14 O.D.	21	1⅜	18¾	12	1	1⅛
15 O.D.	22¼	1⅜	20	16	1	1⅛
16 O.D.	23½	1 7/16	21¼	16	1	1⅛
18 O.D.	25	1 9/16	22¾	16	1⅛	1¼
20 O.D.	27½	1 11/16	25	20	1⅛	1¼
22 O.D.	29½	1 13/16	27¼	20	1⅛	1¼
24 O.D.	32	1⅞	29½	20	1⅛	1¼
26 O.D.	34¼	2	31¾	24	1¼	1⅜
28 O.D.	36½	2 1/16	34	28	1¼	1⅜
30 O.D.	38¾	2⅛	36	28	1⅜	1½

Bolt holes should straddle center lines. Flanges should be plain faced.

"THE 1912 U. S. STANDARD"
SCHEDULE OF EXTRA HEAVY FLANGES FOR EXTRA HEAVY FITTINGS AND VALVES

FOR STEAM PRESSURES FROM 125 TO 250 LBS. PER SQUARE INCH
ADOPTED BY THE NATIONAL ASSOCIATION OF MASTER STEAM AND HOT WATER FITTERS
THE AMERICAN SOCIETY OF MECHANICAL ENGINEERS, THE AMERICAN SOCIETY OF HEATING AND VENTILATING ENGINEERS

All dimensions are in inches

Size of Pipe	Diameter of Flange	Thickness of Flange	Diameter of Bolt Circle	Number of Bolts	Size of Bolts	Diameter of Bolt Holes
1	4½	11/16	3¼	4	½	⅝
1¼	5	¾	3¾	4	½	⅝
1½	6	13/16	4½	4	⅝	¾
2	6½	⅞	5	4	⅝	¾
2½	7½	1	5⅞	4	¾	⅞
3	8¼	1⅛	6⅝	8	¾	⅞
3½	9	1 3/16	7¼	8	¾	⅞
4	10	1¼	7⅞	8	¾	⅞
4½	10½	1 5/16	8½	8	¾	⅞
5	11	1⅜	9¼	8	¾	⅞
6	12½	1 7/16	10⅝	12	¾	⅞
7	14	1½	11⅞	12	⅞	1
8	15	1⅝	13	12	⅞	1
9	16¾	1¾	14	12	1	1⅛
10	18¾	1⅞	15¾	16	1	1⅛
12	20¾	2	17¾	16	1⅛	1¼
14 O.D.	23½	2⅛	20¼	20	1¼	1⅜
15 O.D.	25	2 3/16	21½	20	1¼	1⅜
16 O.D.	26	2¼	22½	20	1⅜	1½
18 O.D.	28½	2⅜	24¾	24	1⅜	1½
20 O.D.	31	2½	27	24	1½	1⅝
22 O.D.	33	2⅝	29¼	28	1½	1⅝
24 O.D.	36	2¾	32	28	1⅝	1¾

Bolt Holes should straddle center lines. Square Head Bolts with hexagonal nuts are recommended. Flanges should have 1/16 inch raised face for gaskets.

A Color Scheme for Pipe Lines

Reprinted from *The Locomotive*, April, 1908.

The multiplicity of pipe lines in the modern power plant is confusing, to say the least. Some simple method of easy and certain identification, universally adopted, would be a welcome step in advance. It would not only facilitate the regular work of the attendants in charge, but would also reduce the probability of mistakes in handling valves, and in times of emergency it might prevent serious accidents. Furthermore, when a change of engineers is made, the new man would grasp the situation quicker, and there need be no interruption of the service, or even a drop in the efficiency. Such a system would be also of decided advantage to inspectors when making their regular visits, — whether for the municipal, insurance, or other authorities.

Some attempts in this direction have been made by attaching labels or tags to valves. The United States Government requires all pipe lines in distilleries to be painted in colors, in accordance with an established system. Something has been done also in power plants in this direction, but so far as the writer knows, no complete scheme has as yet been worked out, or proposed, for general adoption.

The writer was confronted with this problem recently, when designing the power and service plant of the new Hamburger Department Store at Los Angeles, Cal., of some 1,600 horse-power capacity. Here there were not only the usual steam, exhaust, and feed lines, but a sprinkler system, iced-water distribution, air lines (both compressed and vacuum), ammonia and brine lines for refrigeration, and oil, for both fuel and lubrication. The solution finally worked out was as follows, previous color schemes being adopted as far as possible:

Steam:	
High and medium pressure	White
Low-pressure heating lines	Aluminum bronze
Exhaust lines	Gray
Hot Water:	
Returns from heating system	Aluminum bronze
House supply	Maroon
Boiler feed	Bright red
Pure drains from high-pressure and exhaust headdrips	Pink
Impure drips, overflows, and boiler blow offs, to blow off tank	Black

Cold Water:

From city mains or deep well, and general house distribution .. Light blue
Sprinkler lines, including tank, excess pressure, and draining systems ..Blue

Iced-Water:

Drinking water lines .... Dark or navy blue

Air:

Vacuum heating and house-cleaning lines .... Light green
Compressed .... Dark green

Refrigerating:

Ammonia, gas .... Yellow
Ammonia, liquid .... Bronze
Brine .... Orange

Oil:

Lubricating system .... Light brown
Boiler supply .... Dark brown

These colors are to be applied to the pipe lines after completion and test. They will be applied directly to the pipes themselves where they are left bare, and on top of the finished covering for all others.

The pneumatic-tube cash system, being of polished brass pipe, was not thought to need special coloring.

Pipe lines for hydraulic elevators, when installed, might be violet. Still further differentiation, if desired, could be secured by painting the valves and fittings a different color from the pipe itself.

Gas pipes, where exposed, might be left black, as there would be no danger of confusing them with impure drains.

Care must be taken, of course, to secure colors that will not fade under heat.

The foregoing plan is believed to be consistent and reasonably complete, and is recommended for general adoption. — William H. Bryan, in *Steam.*

Various Forms of Filter

Charles L. Hubbard, Boston: "The value of cloth filters in connection with ventilating work depends principally upon the available space for extended surfaces, and upon the frequency with which the filters are cleaned. For large volumes of air, and in cases where the expense does not prohibit it, a good form of air washer and purifier is much to be preferred to any of the dry filters in use in this country.

There are many cases where a comparatively small quantity of air is required, as in the ventilation of isolated offices, banking rooms, etc., where cloth screens or filters may be made to do good service when cleaned at frequent intervals.

Although cheese-cloth is commonly used for this purpose, the writer has found a form of bunting, such as is used in outdoor decoration, more satisfactory. The threads have a harder finish and lack the fuzzy appearance of cheese-cloth. This material bears handling and cleaning well, does not offer excessive resistance to the air, and is of sufficiently fine mesh to remove the coarser particles from the air, such as soot, street dirt, etc.

The finer the cloth the more effective it is as a filter, but at the same time it cuts down the air supply, so it is necessary in designing a filter to compromise between the two to some extent. In fan work, with cheese-cloth or bunting filters of not too fine a mesh and kept reasonably clean, we may figure on an area such that the velocity through them will not have to exceed 60 to 80 ft. per minute. If there is ample space, increase the area, as this will reduce the resistance, thus increasing the volume of air, and also the length of the periods between cleaning.

In designing a filter of this kind the two important points are evidently to get the largest filter surface into the smallest space,

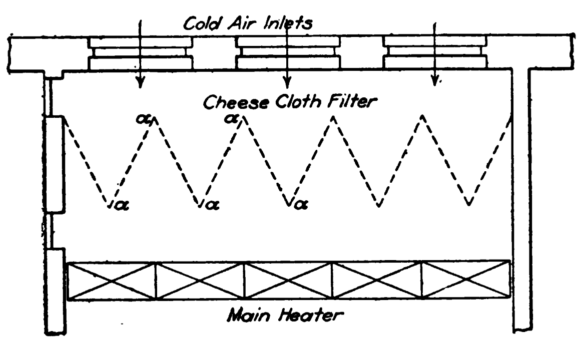


FIG. 220

and also to make the filters easily removable for cleaning. The two forms in most common use are those in which the cloth is stretched on frames, and those made in the form of bags. Fig. 220

shows in plan one of the former, made in sections and arranged in saw-tooth form to increase the area. In this case angle iron uprights are placed at the points a, a, a, etc., extending from floor to ceiling. The cloth is tacked to wooden frames, which are inserted between the uprights and form the sides of the teeth. A sectional detail through two of the uprights is shown in Fig. 221, and illustrates the

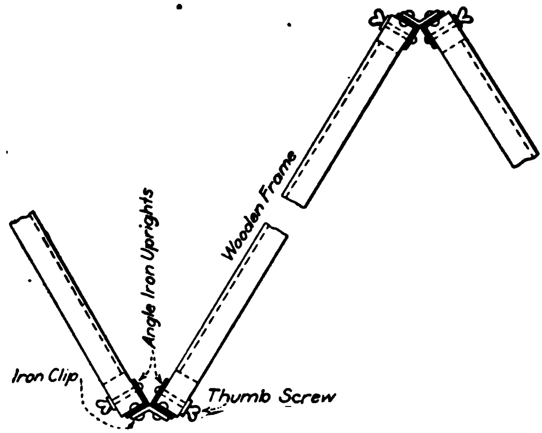


FIG. 221

method of attaching the frames to the angle irons. Each upright is formed of two angle irons placed as shown, and connected at three points by iron angles or clips riveted to them, as indicated. These uprights form recessed frames into which the screens or filters fit, where they are fastened in place by thumbscrews as shown. Each vertical section of the filter is best made in two or more parts, so they may be easily removed for cleaning.

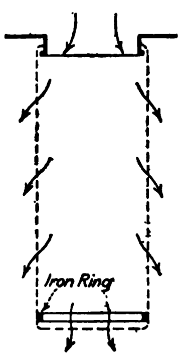


FIG. 222

Fig. 222 shows a filter where the cloth is made in the form of a bag instead of being stretched on wooden frames, as in the case just described. The general method of making up a filter of this kind and its relation to the fan and heater are shown in Figs. 223 and 224. The size and number of the bags will depend upon the volume of air to be filtered. Sometimes, when there is not space for this near the heater, it is supported upon the outside of the build-

ing at the cold air inlet. As there is nothing to freeze, the only requirement is that it be convenient of access for cleaning. Bag filters of this form are hung in a vertical position, being attached

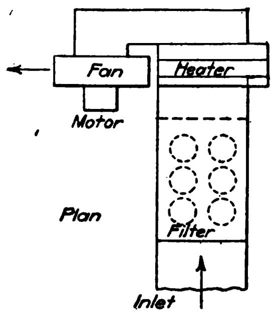


FIG. 223

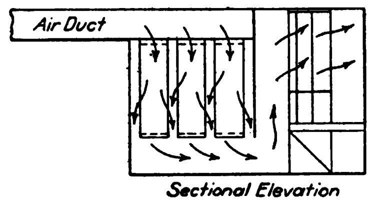


FIG. 224

by means of a cord or strap over an iron mouthpiece having a wired edge to hold it in place. Iron rings placed in the bottoms of the bags, as shown, serve to steady them and prevent them from becoming tangled with each other.

Sometimes the available space for a filter is a long and narrow room in a low basement. In this case it is usually more convenient to use bags of a considerable length supported in a horizontal position. Fig. 225 shows a filter bag arranged in this manner. The

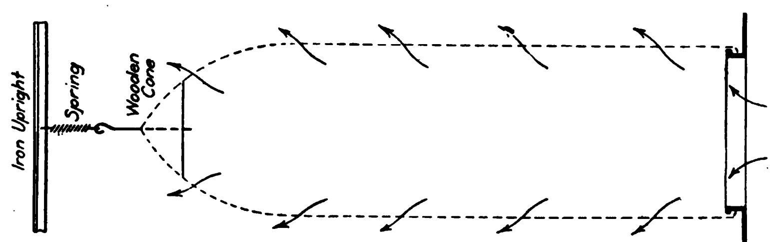


FIG. 225

open end is attached to the metal mouthpiece the same as for a vertical bag, but instead of using an iron hoop at the other end, the bag is tapered and tacked to a wooden cone, which in turn is attached by means of a hook and coil spring to a light iron upright. In arranging the bags, in any case, sufficient space should be left between them for the free movement of the air.

Cloth filters are not well adapted for use in connection with gravity heating, owing to the slight pressure available for overcoming the added resistance except in the case of strong winds. If they are used, cloth of a coarse mesh should be employed, and frequent cleaning should be practiced. The writer's experience would lead him to double the area that is used for fan work for an equal volume of air, when possible."

Obviating Noises in Fan Systems

Charles L. Hubbard, Boston: "The method which has given the greatest satisfaction to the writer has been to avoid vibration at the fan so far as possible rather than to try and absorb it by the use of flexible couplings. If there is a pounding in the engine or a rattle to the fan it is pretty sure to be carried through the airways, regardless of any flexible connection which may be used to intercept it. The principal points to be observed in preventing vibrations or noises which may be communicated to the air ducts are here mentioned. First the engine or motor used for driving the fan should rest upon a solid foundation, and it is well to place between the bed-piece of the machine and the masonry of the foundation a sound deadener, composed of several layers of hair felt, between two sheets of lead, so folded over as to protect the edges of the felt. This should be drawn down quite solid by means of the anchor bolts. See Fig. 226.

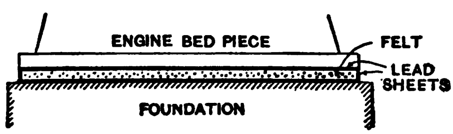


Fig. 226

A good way to prevent vibration from a high-speed motor is to build an 8-in. brick wall around the motor foundation, about 8 in. from it, and fill the intervening space with moist sand, tamped hard, as indicated in Fig. 227.

Noises within the engine itself are usually caused either by a slight play of the piston upon the rod or by a looseness of the brasses, either at the wrist-pin or crank-pin. Care should be taken to use a rather light and pliable belt of good width instead of a heavier narrow one, and the joint should be lapped and cemented instead of laced. Noise and vibration within the fan may be produced by an unbal-

anced fan wheel, too much end play to the shaft, or loose bolts or rivets. Attention should then be given to the sheet iron work of the duct adjacent to the fan. This should be of good weight, rarely less than No. 18 or possibly No. 20, if the duct is of moderate size, and it should be well stiffened with V strips or light angle iron, and rigidly fastened to the ceiling or walls of the basement. With vibration properly eliminated from the fan and engine, and the duct well constructed, there should be no special difficulty from vibration with the fan and duct rigidly connected.

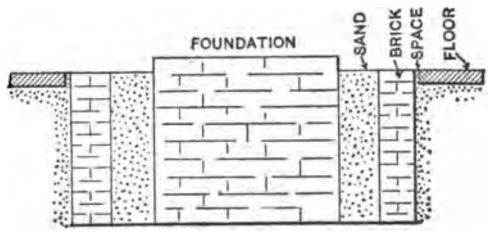


FIG. 227

The roaring noise so commonly heard in the main distributing duct is caused by the air impinging upon the comparatively thin lower edge of the blower outlet, as indicated by the arrow in Fig. 228, which represents a section through the outlet from a fan casing. Obviously, if this noise can be done away with by changing the form of outlet, it is much better than trying to smother it with a sleeve of canvas or other flexible material, which only prevents the vibration from being communicated to the ironwork without reducing to any extent the noise at the fan. Fig. 229 shows a form of fan casing with a V-shaped or "vanishing" outlet. Fan casings constructed on these lines produce but little of the roaring noise so common with the usual pattern. The writer knows of many fan systems in schools and churches where the fan outlet is constructed in this manner, and the sheet iron distributing duct bolted directly to the casing, and in every case they operate satisfactorily without objectionable noise or vibration.

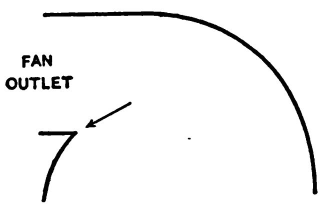


FIG. 228

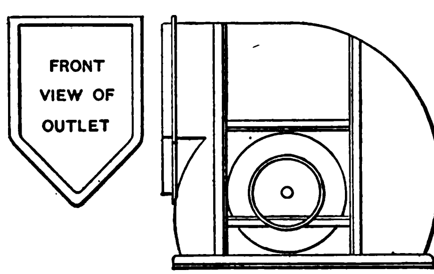


FIG. 229

Fig. 230 shows the method of connecting the duct to the fan outlet; the V piece is usually joined to the duct at an angle of about 30 degrees, as shown. Sometimes it is necessary to have the fan discharge into a large plenum chamber constructed of galvanized iron

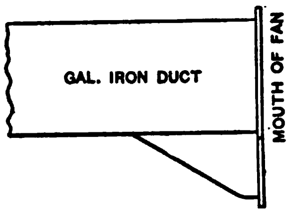


FIG. 230

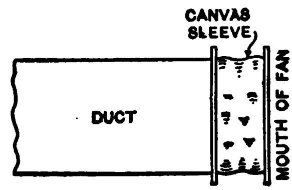


FIG. 231

where there is a tendency to vibration. In certain cases of this kind it may be necessary to insert a flexible sleeve between the fan and ironwork. Usually a sleeve 8 to 12 in. in length of heavy canvas securely attached to the fan outlet and air duct, as shown in Fig. 231, is all that is necessary to break up the vibrations. The elaborate bellows arrangements sometimes used seem hardly necessary for this purpose. Fig. 232 shows a satisfactory way of attaching the cloth sleeve to the ironwork. For convenience, the ends of the sleeves can first be tacked to the wooden frames, and these in turn bolted to the iron flanges."

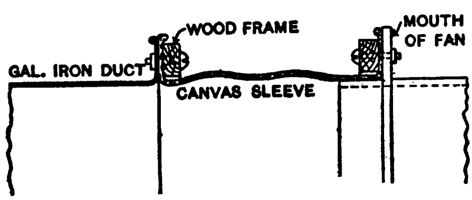


FIG. 232

Expansion of Wrought Iron Pipe

Howard's tests at the Watertown Arsenal show that wrought iron expands 0.0000067302 of its length for each degree F. rise in temperature through which it is heated.

On this basis if 100 ft. of pipe is made up in freezing weather for example 32° F. it will expand approximately 1.58 inches when filled with steam at 5 lbs. pressure.

If filled with steam of 100 lbs. pressure the pipe having been installed at say 32° F. it will expand approximately 2.46 inches.

Table showing amount in inches a pipe originally 100 ft. in length will expand when heated the number of degrees stated:

Original length of pipe	50°	100°	150°	200°	250°	300°
	Amount of expansion expressed in inches					
100′	0.4	0.8	1.21	1.61	2.01	2.42

Approximate steam temperatures corresponding to given gauge pressures are as follows:

1 lb.	216° F	100 lb.	337° F
5 lb.	228° F	150 lb.	365° F
25 lb.	267° F	200 lb.	388° F
50 lb.	298° F	255 lb.	407° F
75 lb.	320° F		

TABLE OF DIMENSIONS OF

STANDARD WEIGHT WROUGHT-IRON PIPE

Inside Diameter.	Actual Outside Diameter.	Thickness.	Actual Inside Diameter.	Inside Circumference.	Outside Circumference.	Length of Pipe per square foot of inside surface.	Length of Pipe per square foot of outside surface.	Inside Area.	Outside Area.	Length of Pipe containing one cubic foot.	Weight per foot.	No. of threads per inch of screw.	Taper of threads per inch of screw.
Ins.	Inches.	Inches.	Inches.	Inches.	Inches.	Feet.	Feet.	Inches.	Inches.	Feet.	Lbs.		In.
$\frac{1}{8}$	0.405	0.068	0.270	0.848	1.272	14.15	9.44	0.0572	0.129	2500.	0.243	27	$\frac{1}{32}$
$\frac{1}{4}$	0.54	0.088	0.364	1.144	1.696	10.50	7.075	0.1041	0.229	1385.	0.422	18	$\frac{1}{32}$
$\frac{3}{8}$	0.675	0.091	0.494	1.552	2.121	7.67	5.657	0.1916	0.358	751.5	0.561	18	$\frac{1}{32}$
$\frac{1}{2}$	0.84	0.109	0.623	1.957	2.652	6.13	4.502	0.3048	0.554	472.4	0.845	14	$\frac{1}{32}$
$\frac{3}{4}$	1.05	0.113	0.824	2.589	3.299	4.635	3.637	0.5333	0.866	270.	1.126	14	$\frac{1}{32}$
1	1.315	0.134	1.048	3.292	4.134	3.679	2.903	0.8627	1.357	166.9	1.670	11½	$\frac{1}{32}$
1¼	1.66	0.140	1.380	4.335	5.215	2.768	2.301	1.496	2.164	96.25	2.258	11½	$\frac{1}{32}$
1½	1.90	0.145	1.611	5.061	5.969	2.371	2.01	2.038	2.835	70.65	2.694	11½	$\frac{1}{32}$
2	2.375	0.154	2.067	6.494	7.461	1.848	1.611	3.355	4.430	42.36	3.600	11½	$\frac{1}{32}$
2½	2.875	0.204	2.468	7.754	9.032	1.547	1.328	4.783	6.491	30.11	5.773	8	$\frac{1}{32}$
3	3.50	0.217	3.067	9.636	10.996	1.245	1.091	7.388	9.621	19.49	7.547	8	$\frac{1}{32}$
3½	4.00	0.226	3.548	11.146	12.566	1.077	0.955	9.887	12.566	14.56	9.055	8	$\frac{1}{32}$
4	4.50	0.237	4.026	12.648	14.137	0.949	0.849	12.730	15.904	11.31	10.66	8	$\frac{1}{32}$
4½	5.00	0.247	4.508	14.153	15.708	0.848	0.765	15.939	19.635	9.03	12.34	8	$\frac{1}{32}$
5	5.563	0.259	5.045	15.849	17.475	0.757	0.629	19.990	24.299	7.20	14.50	8	$\frac{1}{32}$
6	6.625	0.280	6.065	19.054	20.813	0.63	0.577	28.889	34.471	4.98	18.767	8	$\frac{1}{32}$
7	7.625	0.301	7.023	22.063	23.954	0.544	0.595	38.737	45.663	3.72	23.27	8	$\frac{1}{32}$
8	8.625	0.322	7.982	25.076	27.096	0.478	0.444	50.039	58.426	2.88	28.177	8	$\frac{1}{32}$
9	9.625	0.344	9.001	28.277	30.433	0.425	0.394	63.633	73.715	2.26	33.70	8	$\frac{1}{32}$
10	10.75	0.366	10.019	31.475	33.772	0.381	0.355	78.838	90.762	1.80	40.06	8	$\frac{1}{32}$
11	12.00	0.375	11.25	35.343	37.699	0.340	0.318	98.942	113.097	1.455	45.95	8	$\frac{1}{32}$
12	12.75	0.375	12.000	38.264	40.840	0.313	0.293	116.535	132.782	1.235	48.98	8	$\frac{1}{32}$
...	14.00	0.375	13.25	41.268	43.982	0.290	0.273	134.582	153.938	1.069	53.92	8	$\frac{1}{32}$
...	15.00	0.375	14.25	44.271	47.124	0.271	0.254	155.968	176.715	.923	57.89	8	$\frac{1}{32}$
...	16.00	0.375	15.25	47.274	50.265	0.254	0.238	177.867	201.062	.809	61.77	8	$\frac{1}{32}$
...	17.00	0.375	16.25	51.05	53.40	....	....	.....	.....	...	....	...	..
...	18.00	0.375	17.25	53.281	56.548	0.225	0.212	225.907	254.469	.638	69.66	...	..
...	20.00	0.375	19.25	59.288	62.832	0.202	0.191	279.720	314.160	.515	77.57	...	..
...	21.00	0.375	20.25	63.61	65.97	....	....	.....	.....	..	....	...	..
...	22.00	0.375	21.25	66.759	69.115	0.179	0.174	354.66	380.134	.406	85.47	...	..
..	24.00	0.375	23.25	73.04	75.39	0.164	0.159	424.56	452.39	.339	93.37	...	..

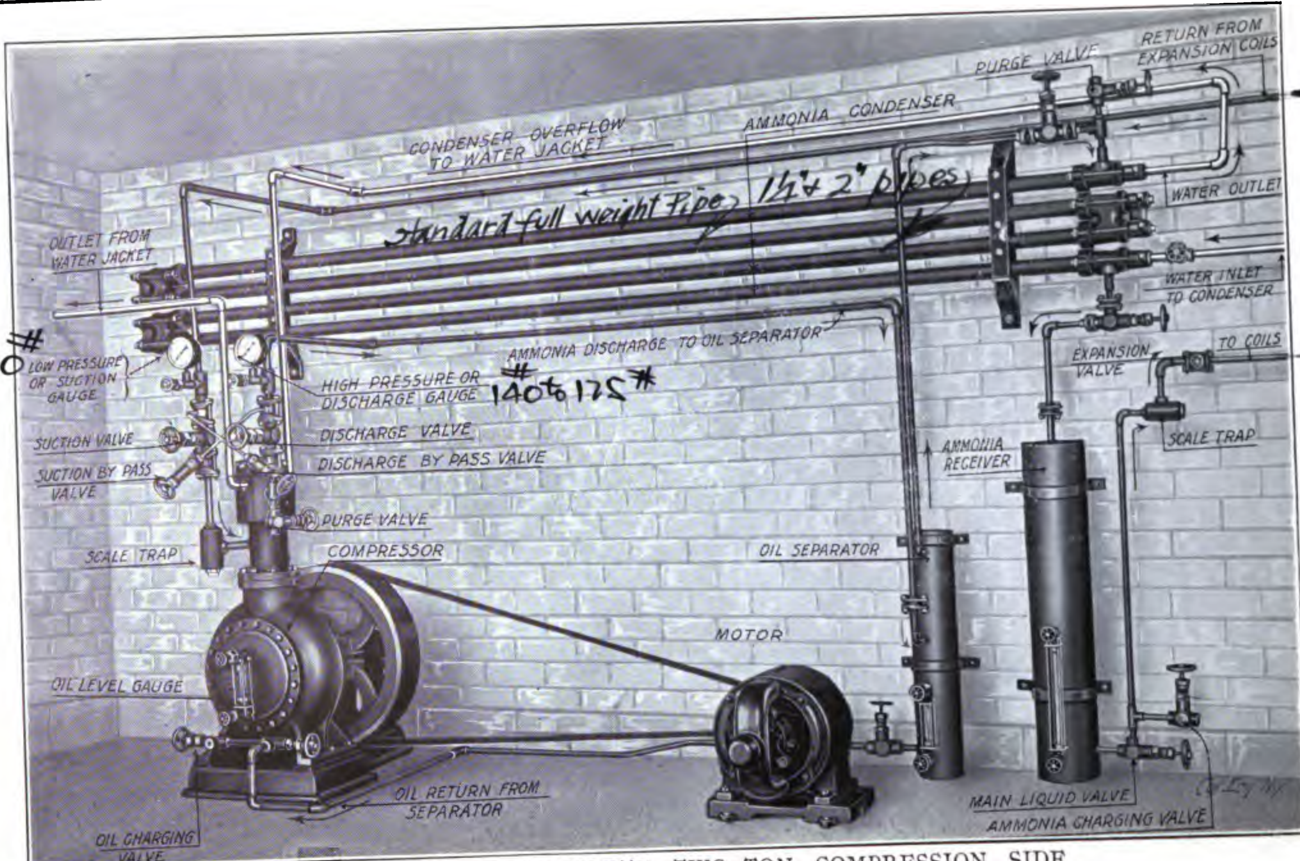
1¼ and smaller proved to 300 lbs. per square inch by hydraulic pressure.

1½ and larger proved to 500 lbs. per square inch by hydraulic pressure.

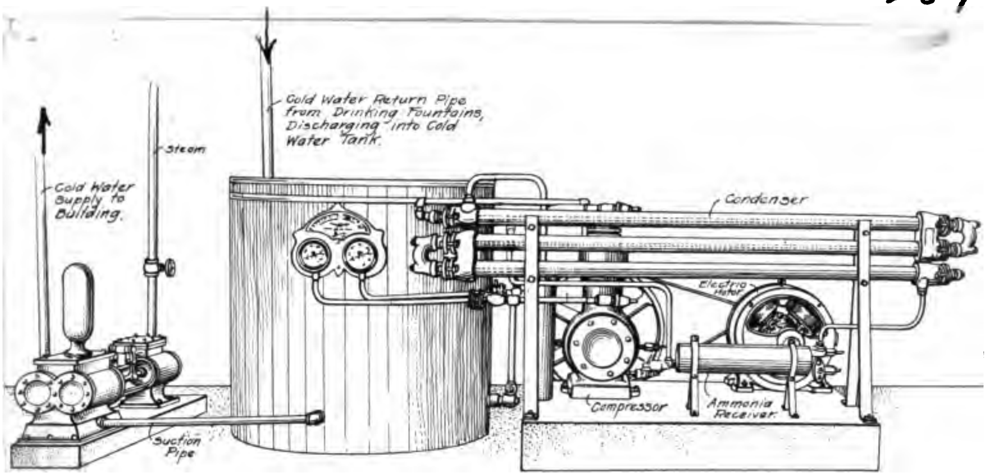
NOTE: Table compiled by Walworth Mfg. Co.

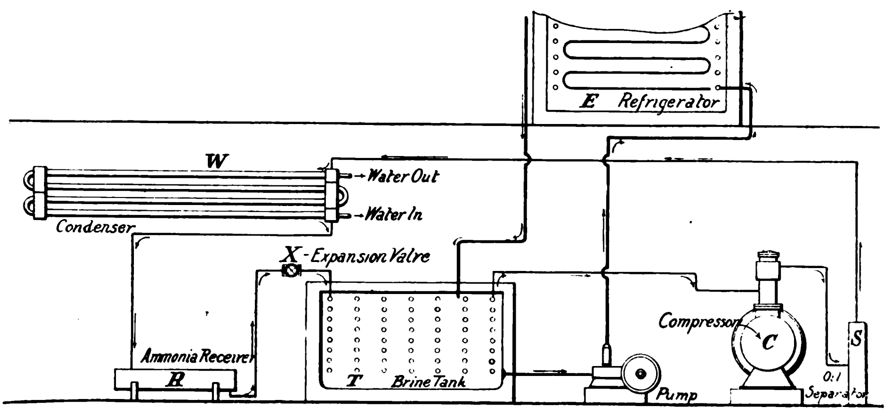
INDEX

786



INSTALLATION OF COMPLETE TWO-TON COMPRESSION SIDE.


Cold Water Return Pipe from Drinking Fountains, Discharging into Cold Water Tank.
Steam
Cold Water Supply to Building.
Condenser
Electric Motor
Compressor
Ammonia Receiver
Suction Pipe


E Refrigerator
W
Water Out
Water In
Condenser
X - Expansion Valve
Ammonia Receiver
R
T Brine Tank
Compressor
C
S
Pump
Oil Separator